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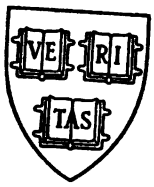

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249.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE SOUTH WALES COAL-FIELD.

PART I.

THE COUNTRY AROUND

NEWPORT,

MONMOUTHSHIRE.

BEING AN ACCOUNT OF THE REGION COMPRISED IN SHEET 249 OF THE MAP.

BY

AUBREY STRAHAN, M.A., F.G.S.

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PREFACE.

This Memoir is the first of a series which it is proposed to issue in explanation of the new Geological Survey Maps of the South Wales Coal-field. This great industrial district was one of the earliest to be examined after the institution of the Geological Survey, as a branch of the Ordnance Survey in 1835. Much of it was mapped by Sir Henry De la Beche himself, the first Director-General, but the staff included also Professor John Phillips, Mr. D. H. Williams, Mr. (afterwards Sir) Andrew C. Ramsay, Mr. W. T. Aveline, Mr. J. Rees, and Mr. T. E. James. An important area, however, extending from Cwmavon to Carmarthen Bay had already been mapped upon the one-inch Ordnance map by Mr. (afterwards Sir) William E. Logan, and it was arranged that not only should his mapping be incorporated with the official work of the Geological Survey, but that Logan himself should become a member of the Staff.

Few records exist as to the distribution of the Staff at that early time, but so far as regards the area described in the following pages it is known to have been geologically mapped by De la Beche and Williams between the years 1837 and 1845.

In June 1891, it having been represented in the House of Commons that the original maps, admirable as they were pronounced to be at the time of their production, had become obsolete both in topography and geology, a re-survey of the whole area was sanctioned. Within five weeks thereafter this work was begun by Mr. Strahan in the neighbourhood of Newport and Pontypool, and the Sheets 249 and 232 of the New Series of Ordnance Maps on the scale of one inch to a mile were published in 1895–96. In 1893 Mr. Strahan was joined by Mr. Walcot Gibson, who surveyed a small portion of the north-west corner of Sheet 249 and part of Sheet 232, and in 1894 by Mr. J. R. Dakyns who was engaged in the northern part of Sheet 232. Subsequently this force was increased by the addition of Mr. R. H. Tiddeman and Mr. T. C. Cantrill, who have been engaged further to the south and west in the ground comprised in Sheets, 231, 248, and 263. The present Memoir has been prepared by Mr. Strahan, and the list of fossils have been revised by Mr. E. T. Newton and Dr. F. L. Kitchin.

The original Geological Survey of South Wales was unaccompanied by detailed explanatory Memoirs, but much general information was introduced by De la Beche into his treatise "On the Formation of the Rocks in South Wales and South Western England," which forms part of the first volume of the Memoirs of the Geological Survey. Analyses of the Iron Ores, at that time extensively worked, and lists of the interesting fossils contained in them appeared in the same Memoirs (The Iron Ores of Great Britain, Part III.). A First Report on the Coals suited to the Steam Navy, accompanied by analyses in which the Welsh Coals are discussed, was drawn up by Sir Henry De la Beche and Dr. Lyon (afterwards Lord) Playfair (Chemist to the Geological Survey), and was presented to Parliament. It was published as a Blue Book in 1848, and in the same year appeared in the Second Part of the Second Volume of the Memoirs of the Geological Survey. It was followed by further researches on the same subject by the same authors, which were embodied in a Second (1849), and Third Report (1851), also presented to Parliament, and published among the Parliamentary Papers. Among

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the early contributions of the Geological Survey to the Geology of South Wales, reference may also be made to an account of the Usk inlier of Silurian rocks and of their fossils, which was given by Professor John Phillips, in his Essay on the Malvern Hills, in Part I. of the Second Volume of the Memoirs.

One of the results of the present re-survey has been the sub-division of great masses of strata hitherto grouped together. The Old Red Sandstone of South Wales has been shown to include representatives of both the Upper and Lower divisions of other parts of the Kingdom, though, so far as at present examined, the formation appears to exhibit an unbroken sequence such as occurs nowhere else, unless among equivalent strata in Devonshire. The true relations of the Upper and Lower Old Red Sandstone to one another, and to the formations above and below them, can only be elucidated by the examination of a wide area.

The Coal-measures, hitherto represented by one colour only on the map, have long been known to include a mass of sandstone by which an upper is separated from a lower series of coal-producing measures. The representation of these three sub-divisions by colour on the map has served well to illustrate the structure of the Coal-field. The anticlinal and synclinal folds into which the measures have been thrown, and the faults by which they are cut through have been traced out with an amount of detail which was impossible to the original surveyors. It was only after the progress of mining had thrown more light on the geological structure of the ground, and maps on the scale of six inches to a mile were available for use in the field that such a task could be undertaken. The importance of an accurate knowledge of the structure of the Coal-field in view of future mining operations can hardly be overestimated, and an instance is given in this Memoir where many thousands of pounds were wasted for want of it.

While the revision is in progress the boundaries of the Superficial Deposits are traced at the same time as those of the solid rocks underneath, and are shown by colour on a "Drift Edition" of the map. The examination of the Glacial phenomena has led to results of much interest.

At present the map is published on the one-inch scale only, in two editions, one of which ("Solid Rocks Edition") shows the distribution and connections of the solid rocks, apart from the covering of superficial deposits that so often obscures them; the other ("Drift Edition") represents these deposits as they are distributed over the district, and only marks the solid rocks where they lie bare at the surface.

Manuscript copies of the original six-inch field maps are deposited in the Geological Survey Office, where they can be consulted, and copies can be supplied when desired at the cost of drawing and colouring. One Sheet of Vertical Sections (No. 80) has been published in illustration of the particular area described in the present Memoir.

Our thanks are due to a large number of Colliery Managers, Mining Engineers, and Surveyors for assistance given by them during the re-survey of the Coal-measures. Information and access to plans have in all cases been freely accorded to us.

ARCH. GEIKIE,
Director-General.

Geological Survey Office,
28, Jermyn Street, London,
25th November, 1899.

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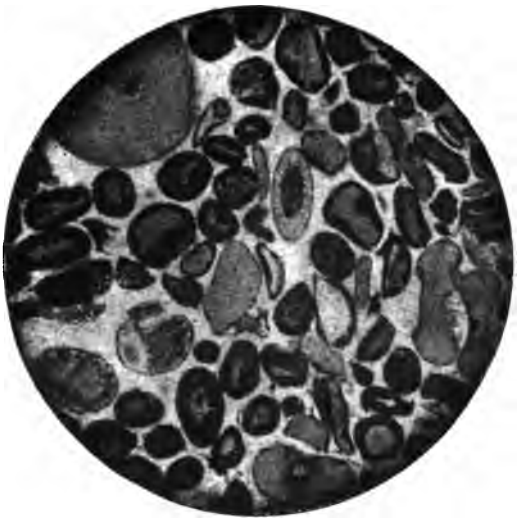

(A) Section of the Lower Limestone, Risca.

(B) Section of the Rhubina Iron Ore.

MICROSCOPIC SECTIONS OF CARBONIFEROUS LIMESTONE
MAGNIFIED TEN DIAMETERS.

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CHAPTER I.

INTRODUCTION.

Of the 216 square miles included in this map about 100 are occupied by the south-eastern part of the South Wales Coal Field, the remainder consisting chiefly of older rocks, but partly of the Liassic and Triassic strata which crop out along the margin of the maritime marsh. The oldest rock exposed is the Wenlock Shale of the Usk Inlier; this passes gradually up into the Ludlow group, but the richly fossiliferous mudstones which constitute the highest visible part of the Ludlow strata are succeeded somewhat abruptly by a red hackly grit belonging to the Old Red Sandstone. Here there is a break in the palæontological and possibly in the stratigraphical sequence, but thence up to the highest Coal Measures no evidence of any unconformity has been detected, though there is good reason to think that the Upper and Lower Old Red Sandstone, between which there is unconformity elsewhere, are both represented in the Old Red strata of South Wales. The portion of the Coal Field lying within the map includes the Blackwood and Caerphilly Basins in which some of the best house-coals of South Wales have been worked, that portion of the South Crop which extends from Pontypool to beyond Walnut Tree, and the lower parts of the Ebbw, Sirhowy, Rhymney, and Taff Valleys.

Physical Features.

The Coal Field is drained by a series of rivers which traverse it from north to south regardless of its geological structure. Most of them rise in the north crop of the Millstone Grit, but the Taff comes right through from the Old Red Sandstone of Brecknock. The Usk, a small part of which falls within the area under description, skirts the north-eastern corner of the Coal Field and enters the Channel near Newport, cutting right across the area of upheaval in which the Silurian rocks reach the surface. It is obvious, therefore, that the earth-movements by which the older rocks have been thrown, on the one hand into a syncline, and on the other into an anticline, have had no share in determining the lines of drainage. A discussion of the origin of the river-system of South Wales would be out of place in the present volume, but it may be pointed out that the valleys could not have been more conveniently arranged for the carriage of the coal from the interior of the Field to the ports of shipment. The exits from the "hills," as the Coal Field has come to be called, break through the ridge of the South Crop at fairly regular intervals and in the following order:—

At Pontypool the Afon Lwyd, which rises in the North Crop at Blaenavon.

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At Risca the Ebbw, which, with its tributaries, the Sirhowy and Ebbw-fâch, comes through from Tredegar, Ebbw Vale, and Bryn Mawr.

At Machen the Rhymney, which comes down from Rhymney and Fochrhiw, and receives also the Aber Valley.

At Walnut Tree the Taff, which, with its tributaries, the Rhonddas, the Cynon and the Bargoed Taff, descends from Aberdare, Merthyr, and Dowlais.

The highest ground within the map is formed by the Pennant grits. In Mynydd Maen these attain an elevation of 1,557 feet, and elsewhere give rise to fairly extensive moorlands exceeding 1,000 feet in height. The Old Red Sandstone, on the other hand, nowhere reaches that height, though on the north side of the Coal Field it forms the highest points of South Wales, and almost touches 3,000 feet. The Silurian rocks scarcely rise above 600 feet.

CLASSIFICATION AND TABLE OF STRATA.

During the progress of the resurvey it became obvious that a subdivision of the great mass of the Coal Measures was essential to the clear representation of the structure of the Coal Field upon a map, and the distinction by colour of the more or less barren mass of Pennant rock has admirably served this purpose. While adopting a three-fold division, however, we do not imply any correlation with the Upper, Middle and Lower Coal Measures of other regions. The subdivision of the Old Red Sandstone, and a change now made in the horizon at which the base of the Rhætic formation is drawn, will be discussed in the chapters descriptive of those strata. The following list gives in descending order all the subdivisions which are distinguished by colour on the map.:—

TABLE OF STRATA.

Alluvium Peat River Gravels	RECENT AND POST-GLACIAL.
Boulder Clay and contemporaneous Sand and Gravel	GLACIAL.
Lower Lias	LIAS.
Rhætic Beds Keuper Marl (including the Green Marls at its top)	TRIAS.
Sandstones and Shales with the Mynyddislwyn Vein at their base Pennant Grit, with the Tillery Vein at its base Steam-Coal Series	COAL MEASURES.
Grit (the Farewell Rock) Shales Quartz Conglomerates	MILLSTONE GRIT.

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Limestone Shale Limestone	CARBONIFEROUS LIMESTONE.
Red Sandstone with Quartz Conglomerates Red Sandstones Red Marls with thin lenticular Limestones (Cornstones)	OLD RED SANDSTONE.
Ludlow Group Wenlock Limestone Wenlock Shale	UPPER SILURIAN.

GEOLOGICAL STRUCTURE.

The Coal Field at its eastern end assumes the form of an oval basin elongated in an east and west direction, and with a much sharper upturn on its southern than on its northern margin. The steepest inclinations within this map occur along the south-eastern lip of the basin between Pontypool and Risca, where they range from 45° to 80°, and between Risca and Tyn-y-coed, where they vary from 30° to 50°. Both within and without this highly inclined lip the dip rapidly diminishes, and the principal coal-workings are carried on in nearly horizontal strata.

The structure of the basin is further diversified by a series of anticlines and synclines, which generally range east and west, but tend to turn north-eastwards at the eastern end of the Coal Field. The flexures may be enumerated in order from north to south as follows:—

1. The Blackwood syncline passes from near Quaker's Yard through Blackwood and Cefn Crib. It introduces outliers of the upper or Mynyddislwyn Measures, which thin away to a feather-edge on the dip-slopes northwards, but are generally terminated southwards by two large northerly downthrows, known as the Glyn and Gelli-groes Faults. These boundary-faults, together with the Cwm-dows and others proved in the Mynyddislwyn workings, run north-eastwards, that is, parallel to the main flexure.

2. The Pontypridd anticline, which forms one of the chief structural features in the Glamorganshire Coal Field, crosses the Taff at Pontypridd, the Aber Valley half a mile north of Senghenydd, the Rhymney Valley near Taren-y-Morthwyl, and then becomes ill-defined.

3. The Caerphilly and Llantwit syncline crosses the Taff at Willow Ford, the Rhymney Valley south of Bedwas, and then loses itself in Mynydd Machen. This, like the Blackwood syncline, introduces outliers of the supra-Pennant or Mynyddislwyn Measures, one (in Sheet 248) near Llantwit Fardre, another at Caerphilly.

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4. The great uniclinal fold, which has already been mentioned as forming the south-east lip of the basin, may be regarded as the northern side of a high and broad anticline, the axis of which is marked by the outcrops of Silurian strata at Usk, Llanfrechfa, and Cardiff. It includes also some minor flexures, one of which throws the lower limestone into a synclinal form near Castell Coch, while the other causes a series of small rolls in the limestone and Old Red Sandstone near Risca. The main axis of the great Usk anticline is marked not only by the Silurian inliers mentioned above, but by the disposition of the subdivisions of the Old Red Sandstone; for the sandstones and marls with cornstones which rise in succession from beneath the Carboniferous Rocks arch over and take the ground again near Newport and Caerleon, so that it is doubtful whether some of the strata near Christchurch may not belong to the middle or Sandstone division of the Old Red Sandstone.

5. The south-easterly dip assumed by these strata points to there being a syncline under the marsh-land bordering the Bristol Channel, but the structure of the older rocks is there completely concealed by Secondary strata and alluvium.

Upon the flexures enumerated above there has been superimposed a series of faults having a general north-north-west direction. This fault-system, which forms one of the most conspicuous features in the structure of South Wales, can be proved to be partly if not wholly of post-Liassic age, whereas the flexures, across which they cut nearly at right angles, are of pre-Triassic age. The determination of this fact is of the greatest importance with regard to the possible existence of concealed coal-fields beneath the Secondary Rocks.

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CHAPTER II.

UPPER SILURIAN ROCKS.

These strata consist in the main of mudstones, becoming, however, sandy in parts, and even containing bands of hard compact sandstone. Limestones are subordinate and are more often represented by oval concretions than continuous bands, even the Wenlock Limestone, which occasionally reaches a thickness of 20 ft., being impersistent. In this respect, and especially in the presence of sandstones, the strata differ so far from those of Woolhope, Dudley, and Malvern as to have been originally assigned in part to the Caradoc and Llandilo series.* That they contain a Wenlock fauna even in the lowest beds exposed was first ascertained by John Phillips.† The strata are slightly folded and faulted, but devoid of any traces of cleavage.

The inlier, in which they appear at the surface, assumes a roughly oval form extending 8½ miles in a direction somewhat east of north, from Clytha Castle to Llandegveth, with three small inliers further south. Though its central part is generally occupied by the oldest rocks and its margin by newer strata, it is far from being a simple dome of elevation; for not only is it bounded both on the north-east and south-west by faults and sharp upturns which form the continuation of the Pontypool and Risca upturn, but it is traversed by numerous smaller folds which break the symmetry of the outcrops within it. Among the latter may be mentioned an anticline which brings up the Wenlock Limestone at Dowlais, disturbances which shift the outcrop of that rock from Tyn-y-caeau to Cilfigan and from Cefn-ila to near Rhadyr, while in three places west and south-west of Llangibby Castle small outliers of Old Red Sandstone have been faulted or folded in among the Silurian strata. Lastly, a deep faulted syncline of the red formation penetrates the inlier for upwards of a mile near Llandegveth. Between that place and Llanfihangel Pontymoil, however, the Ludlow rocks pass naturally under the Old Red Sandstone and rest naturally upon the Wenlock Limestone of Common Coed-y-paen, thus giving the complete sequence. The breadth of this outcrop is about a mile and a third, which with a dip of 10° would indicate a thickness of about 1,200 ft.; but the constant undulations render such an estimate quite unreliable. Of the thickness of the Wenlock Shale no estimate is possible, for the base of the group is not reached in this inlier.

---

* De la Beche, Memoirs of the Geological Survey, vol. i., p. 22. The spelling here adopted for the name Llandilo is that which is now commonly in use, and which appears on the New Series Ordnance Maps.

† Phillips, Memoirs of the Geological Survey, vol. ii., pp. 201, 202.

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WENLOCK SHALE AND LIMESTONE.

The strata assigned to this subdivision consist mainly of pale grey and blue shales and mudstones, in which concretionary structure and spheroidal weathering are usually conspicuous. They frequently contain nodules of limestone in abundance, as in Craig-y-garcyd (half a mile north of Rhadyr) and near Greenmeadow, while in their upper part they become more sandy and pass into laminated or flaggy buff sandstones, as at Cefn-ila and Glascoed, an unusual feature in the Wenlock Shale which led to a doubt as to the true age of the strata, as already mentioned. The fossils collected by Phillips from Glascoed and Bryn Craig (half a mile east of the church and just beyond the northern margin of this map) are included in the list given on pages 9–15. He remarks of them that "the fossils and sandstones are not only few in number as compared with the ordinary Upper Caradoc bed; they are also not such as are commonly and immediately recognised as characteristic of such."*

Of the Wenlock Limestone there are four distinct outcrops—namely, at Glascoed, at Common Coed-y-paen, south of Cilfigan Park, and at Dowlais. They are separated from one another, but whether through the local dwindling away of the limestone or through faulting it is impossible to say; nor, indeed, is it certain that the rocks exposed at these four localities are precisely on the same horizon, and not lenticular masses wedging in at slightly different levels in the Wenlock strata.

The limestone was formerly burnt for lime, but is now used chiefly for road-metal. It was followed underground north of Glascoed, and the old workings form a line of picturesque caves, the roof of which is formed by about 10 or 11 ft. of mudstone more or less crowded with nodules of limestone, while the rock in requisition was a pure and massive limestone with a thickness of 9 or 10 ft. The workings cease on the north side of Pentre-waun Wood, and for 900 yards there is nothing to indicate any outcrop of limestone, but at Pentre-waun the pits recommence, and the limestone rapidly develops the following section, as shown in a quarry which is indicated on the map by a dip of 7° :—

Pentre-waun.

		ft.	in.
	Mudstone	3	0
Wenlock Limestone	Nodular limestone	4	0
	Massive coarsely crystalline limestone	6	0
	Nodular limestone- - - - 3 ft. to	4	0
	Massive limestone, as above, seen to	12	0

After passing some similar sections west of Tyn-y-caeau we lose the rock again, and have to draw a hypothetical boundary in a north-westerly direction to the south side of Cilfigan Park, where again a series of road-metal quarries exhibit upwards of 8 ft. of massive crystalline limestone overlain by nodular limestone and sandstone of variable thickness. Again the same difficulty presents itself in tracing the Cefn-ila outcrop north-

* Memoirs of the Geological Survey, vol. ii., p. 202.

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wards to Rhadyr, and though both here and at Tyn-y-caeau it may be explained away by north-westerly faults with down-throws to the north-east, the various suppositions that the limestone thins out, or that it has been dissolved away at the outcrop, or that its course is diverted by folding, are at least equally credible. In the Cwm Dowlais inlier there are several old pits which serve to prove a quâquâ-versal dip, steeper on the south-east side. The axis of upheaval runs north-north-east, but cannot be traced for more than half a mile.

The limestone is composed chiefly of coarsely crystalline calcite enclosing many encrinites and corals, and is not at all or only slightly dolomitised. The following analysis was made for Mr. F. T. Howard at St. Mungo's College, Glasgow, under the superintendence of Prof. T. Rhymer Marshall:—

Wenlock Limestone, Common Coed-y-Paen.

Free SiO_2	1·48
$Fe\,CO_3$	1·56
Fe_2O_3	0·41
$Mn\,CO_3$	3·19
$Mg\,Co_3$	3·69
Clay	0·23
$Ca\,Co_3$	88·89
Moisture, &c.	0·55
	100·00

LUDLOW BEDS.

These strata consist in the main of dark-grey fossiliferous mudstones with concretions or lenticular bands of limestone. In their upper part they include also bands of brown or buff fine-grained sandstone, more or less fossiliferous, and presenting no resemblance to any part of the Old Red Sandstone. The upper part corresponds, according to Phillips,* to the Upper Ludlow and Aymestry formations, and the lower to the Lower Ludlow, this correlation being founded on fossils collected from the neighbourhood of Coed-duon, Cefn-ila, Dowlais, Llangibby Castle, Coed-y-paen, and the Daren, a great landslip-chasm a mile south-west of Coed-y-paen. The top of the group is best studied between Llandegveth and Pontymoil, for along the faulted boundaries near Llangibby there is always a doubt how much of the formation may be cut out, though in several places the uppermost strata seem to occupy their proper relative position to the Old Red Sandstone, while dipping at angles of 40° to 80° beneath it.

Llandegveth Church stands on the lowest bed of the Old Red Sandstone, a hard, fine-grained quartz-grit which rests immediately upon fossiliferous Ludlow mudstones. The same superposition is seen on the west side of the brook, 250 yards south-west of the Farmer's Arms, and thence for a mile northwards by Llanddewi-fach the grit forms a conspicuous scarp, with the soft Ludlow mudstones cropping out in the slopes. The best opportunity of examining the actual junction is afforded by two small dingles 900 yards south of Llanthewy Court, where the

* Memoirs of the Geological Survey, vol. ii., p. 201.

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grit rests upon tough, irregularly bedded fossiliferous sandstones and sandy mudstones. Though there is no visible discordance between the two formations, the line of demarcation is sharp and the conformity may prove to be more apparent than real. Similar sections, more or less obscured however, occur at Llanthewy Court, in the side of the wood east of Panteg, and around Sluvad and Trostra (not to be confounded with Trostrey east of the Usk), while Trostra Common is formed by a little syncline of grit projecting into the Ludlow area, and reposing directly upon fossiliferous mudstones.

Within half a-mile, however, the grit ends against a fault which throws red and mottled marl of the Old Red Sandstone against Ludlow strata. The course of the fault north-north-eastwards is plainly marked not only by the difference of soil on its two sides, but by the fact that the red marls form a wet heavily wooded tract, which terminates abruptly at the foot of a steep bank of the somewhat barren blue mudstones.

Three small inliers of Ludlow Beds occur south of the main mass. The one south-east of Llandegveth shows fine-grained fossiliferous grit and slightly reddened mudstones faulted up on the west, but dipping eastwards under Old Red grits and marls. Of the two inliers at Llanfrechfa, the northern shows current-bedded encrinital sandstone and highly fossiliferous shales; the other yields *Loxonema* and a large *Orthoceras* in unusual abundance in a rivulet 150 yards south-east of Llanfrechfa House. The boundaries of both are obscure, and the absence of the basement quartz-grit of the Old Red Sandstone suggests that they are not improbably formed by faults.

Mention has already been made of the sharpness of the demarcation between the Old Red Sandstone and the Upper Silurian Rocks. Prof. Jukes, so long ago as 1857, remarked that the Usk strata contained no red beds and showed no graduation up into the Old Red Sandstone, therein differing from the Upper Silurian strata of Llandilo and Llandovery. The fact suggested to him that there may here be an unconformity, and that the passage-beds of other districts may have been denuded away*. Jukes's views did not agree with those of Phillips, expressed nine years before, that the micaceous character and brown colour of some of the Upper Ludlow sandstones indicated a passage up into the Old Red Sandstone†. The subject is one, however, which can be discussed only after an examination of a large number of districts outside the limited area now under description.

List of Fossils from the Upper Silurian Rocks of the Usk and Llanfrechfa Inliers.

The revision, correction for synonomy, and to a considerable extent the compilation of this list, are due to Messrs. E. T.

* *Brit. Assoc. Rep.* for 1857, Trans. Sects., p. 74.

† Memoirs of the Geological Survey, vol. ii., part 1, pp. 203-205.

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Newton and F. L. Kitchin. It has been compiled chiefly from lists given in the Geological Survey Memoir, Vol. II., pt. I., and from specimens preserved in the Museum of Practical Geology. Additions which have been made from other sources are indicated by letters as below:—

D. Monograph on the Fossil Brachiopoda by T. Davidson. *Pal. Soc.*

B. Monograph of the British Fossil Cephalopoda, pt. I., by J. F. Blake. 4to. 1880.

F. Catalogue of the Fossil Cephalopoda in the British Museum, by A. H. Foord and G. C. Crick.

The names of genera and species in square brackets [ ] are those used in the early Survey Memoir, Vol. II., pt. I.

Localities.

The information in square brackets has been added to facilitate reference to the New Series Ordnance Maps.

1. Beech Hill, crest of the hill north of Usk.
2. Bryn Craig [half a mile east of Ton Church].
3. Cilfigan [limestone-quarries].
4. Cilorgyr [limestone-quarries at Common Coed-y-paen].
5. Cock Wood, edge of hill north of Usk.
6. Coed y Pan [Coed-y-paen, Lower Ludlow Beds south of the limestone-quarries].
7. Castle Barn, edge of the hill north of Usk.
8. Cefn Ila, limestone-quarries.
9. Cefn Ila Lodge, road-cutting in Lower Ludlow Beds.
10. Craig y Garcyd [cliff on the west bank of the Usk, east of Monkswood].
11. Darran [the Daren, indicated by the word "Landslip" on the one-inch N.S. map, Sheet 249].
12. Dowlais [Cwm Dowlais].
13. Glascoed [Glascoed Common].
14. Hill Barn, road down the hill 1½ miles north of Usk.
15. Llanbadoc, south of Usk.
16. Llangibby, in road west of the Castle.
17. Llancayo, quarries one mile north of Usk.
18. Prescoed Common [Pentre Waun, half a mile north-west of Coed-y-paen].
19. Radyr [Rhadyr] Mill, shales in cliff.
20. Radyr Hill, sandstone beds.
21. Radyr lime-quarries.
22. Radyr, south of, at Coed dduon.
23. Radyr, south-east of.
24. Russell's Farm, in lane one mile east of Trostrey.
25. Tynewydd [underground quarries near the Church at Ton].
26. Ty-goch [half a mile north-west of Bettws-Newydd Church].
27. Trostra [Trostrey], quarries and cliff under.
28. Tucking Mill [Berthin Brook, south of Monkswood Church].
29. Usk Castle, road-cuttings.
30. Usk, north of, road-cutting near the river.
31. Ysgubor Gwynt, deep cut in lane half a mile north of Llangibby Castle].
32. Llanfrechfa.
33. Garcoed.
34. Usk.

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	Ludlow Beds.	Wenlock Limestone.	Wenlock Shale.
SPONGIÆ—			
Isastræites Kœnigi, *Murch.* -	—	34	33*
ACTINOZOA—			
Alveolites [*Millepora*] repens, *Ed. and Haime* - - -	—	4 25	—
Cœnites juniperinus, *Eichw.* [*Limaria clathrata*] - -	—	4	—
Cyathophyllum articulatum *Wahl.* [C. *cæspitosum*] -	15 16	4	—
Cystiphyllum siluriense (pars) *Lonsd.* - - - - -	—	1 25	—
Favosites aspera, *d'Orb.* [*F. alveolaris*] - - -	15, 16, 17, 30	4 12 25, 27	—
Favosites cristata, *Blum.* [*F. polymorpha*]- - -	—	4	—
Favosites [*Alveolites*] fibrosa, *Goldf.* - - - -	8, 15, 34	3 4, 8, 12, 18, 21, 25, 27	10, 28
Favosites gothlandica, *Linn.* -	1, 15	12, 21, 25	—
Favosites multipora, *Lonsd.* -	—	4	—
Favosites sp. - - - - -	—	Pen-y-lan	—
Halysites catenularia, *Linn.* [*Catenipora escharoides*] -	—	4, 21, 25, 27	—
Heliolites interstinctus, *Linn.* [*Porites pyriformis*] - -	—	21, 27	—
Heliolites megastoma, *M'Coy*	—	34	—
Omphyma Murchisoni, *Ed. & Haime* - - - - -	—	Pen-y-lan	—
Omphyma [*Cyathophyllum*] subturbinatum, *d'Orb.* -	15	4, 25	—
Syringopora biforata, *Lonsd.* [*S. reticulata*] - - -	—	4, 18, 25, 27	
Syringopora fascicularis, *Linn.* [*S. filiformis*] - - -	—	8, 18, 25, 27	—
CRINOIDEA—			
Crotalocrinus [*Cyathocrinites*] rugosus, *Mill.* - - -	—	3	—
Cyathocrinus sp. - - - -	—	34	—
Periechocrinus [*Actinocrinites*] moniliformis, *Mill.* - -	—	3, 4, 8, 12, 27	—
ANNELIDA—			
Cornulites serpularius, *Schloth.*	16, 32	18	2
Serpulites longissimus, *Sow.* -	1	8	—
Trachyderma squamosa, *Salt.* -	34	—	—
CRUSTACEA—			
Ostracoda.			
Beyrichia tuberculata, *Klöd.* -	1, 16	—	—
Beyrichia sp. - - - - -	—	—	34
Trilobita.			
Acidaspis Brighti, *Sow.* - -	16	—	28
Calymene Blumenbachi, *Brong.*	16, 29, 34	—	2
Calymene tuberculosa, *Salt.* -	29, 34	—	10

* Recorded by J. E. Lee, "Notebook of an Amateur Geologist," 1881, p. 63 and plate ccviii.

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——	Ludlow Beds.	Wenlock Limestone.	Wenlock Shale.
Encrinurus [*Cybele*] punctatus, *Brünn.*	—	—	10
Encrinurus [*Cybele*] variolaris, *Brong.*	1, 16, 29	4	10
Homalonotus delphinocephalus, *Green*	—	—	33
Homalonotus Johannis, *Salt.*	—	33	10, 33
Homalonotus Knighti, *Kœnig*	5	—	—
Illænus Barriensis, *Murch.*	—	34	—
Phacops [*Dalmania*] caudatus, *Brünn.*	1 9, 15, 16, 19, 29	4, 25, 27	10
Phacops Downingiæ, *Murch*	—	Pen-y-lan	2, 10, 13
Phacops [*Dalmania*] longicaudatus, *Salt.*	11, 26?, 29	12	2, 10, 28
Proetus latifrons, *M'Coy.*	29	—	34
Eurypterida (Gigantostraca).			
Eurypterus punctatus, *Salt.* sp.	—	33	—
POLYZOA—			
Ceriopora granulosa. *Goldf.*	23	4, 27	—
Fenestella [*Eschara*], scalpellum, *Lonsd.*	—	4, 27	—
Fenestella subantiqua, *d'Orb.* [*F. antiqua*]	—	—	3, 4, 12, 27
Ptilodictya lanceolata, *Goldf.*	—	21?	21?
BRACHIOPODA—			
Atrypa [*Hypothyris*] marginalis, *Dalm.*	—	—	10
Atrypa reticularis, *Linn.*	1, 9, 14, 15, 16, 17, 18, 22, 23, 24, 29, 30.	8, 12, 18, 25, 27, 34	2, 10, 28
Chonetes [*Leptæna*] lepisma *Sow.*	1	—	2
Chonetes minima, *Sow.*	—	—	34
Chonetes striatella, *Dalm.* [*Leptæna sarcinulata*]	16	—	—
Cyrtia exporrecta, *Wahl.* [*Spiriferá trapezoidalis*]	—	34	10
Discina [*Orbicula*] rugata *Sow.*	15, 16, 29	—	—
Leptæna lævigata, *Sow.*	—	—	2
Leptæna transversalis, *Wahl.*	—	34	34
Lingula lata, *Sow.*	—	—	34
Lingula Lewisi, *Sow.*	30	3, 33	28, D3, D28, D34
Meristina [*Atrypa*] didyma, *Dalm.*	12, 15, 16, 30	—	34
Orthis biforata, *Schloth.*	—	—	33
Orthis biloba, *Linn.*	—	—	2, 10
Orthis edgelliana, *Salt.* M.S.	D33	33	33
Orthis elegantula, *Dalm.*	12, 15, 16, 31	4, 8, 25, 27, 33, 34	34
Orthis hybrida, *Sow.*	31	4, 18 25, 27	—
Orthis lunata, *Sow.*	16, 31	8	—

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	Ludlow Beds.	Wenlock Limestone.	Wenlock Shale.
Orthis reversa, *Salt.*	15	—	—
Orthis rustica, *Sow.* var. walsalliensis, *Dav.*	—	—	33
Pentamerus galeatus, *Dalm.*	1, 15	25, 34	—
Pentamerus linguifer, *Sow.*	—	33	—
Pholidops [(*Crania*) implicata] *Sow.* [*Patella implicata*]	—	—	10
Rhynchonella [*Hypothyris*] bidentata, *His.*	—	—	2, 28
Rhynchonella [*Hypothyris*] borealis, *Schloth.*	12, 16, 24	—	10
Rhynchonella deflexa, *Sow.* sp.	—	34	—
Rhynchonella [*Hypothyris*] navicula, *Sow.*	8, 11, 15, 22, 29, 31, 34	—	—
Rhynchonella nucula, *Sow.* [*Hypothyris semisulcata*]	1, 8, 15, 30, 32	3, 88, 25	—
Rhynchonella [*Hypothyris*] Stricklandi, *Sow.*	15	—	2, 28, 33 34
Rhynchonella [*Hypothyris*] Wilsoni, *Sow.*	1, 12, 15, 16, 24, 30	3, 18, 25	2
Spirifera crispa, *His.*	12	D10	10, 23
Spirifera elevata, *Dalm.* [*S. octoplicata, S. ptychodes*]	1, 6, 8, 11, 12, 15, 17, 24, 30	4, 25, 34	2
Spirifera plicatella, *Linn.* [*Spirifera cyrtœna*]	15, 24	33	D10
Spirifera plicatella, *Linn.* var. interlineata, *Sow.*	—	—	10
Strophomena antiquata, *Sow.*	—	D. Pen-y-lan	D. Pen-y-lan.
Stroph. [*Orthis*] applanata, *Salt.*	—	—	10
Stroph. corrugatella, *Dav.* [*Orthis corrugata*]	—	—	10
Stroph. [*Leptœna*] euglypha, *His.*	1, 6, 15, 16, 24	3, 18	2, 10
Stroph. [*Orthis*] filosa, *Sow.*	1, 11, 15, 16, 30, 6, 12, 16, 22, 24	25, 34	10
Strophomena imbrex, *Pander*	—	—	10
Stroph. rhomboidalis, *Wilck.* [*Leptœna depressa*]	1, 6, 15, 24, 30	18	2, 10, 28, 34
Meristina [*Atrypa*] tumida, *Dalm.*	15, 24	3, 25, 27, 34	2, 10, 33*
MOLLUCSA— *Lamellibranchiata.*			
Ambonychia, sp.	—	—	33
Anodontopsis [*Mytilus*] perovalis, *Salt.*	15, 16	—	10
Anodontopsis securiformis, *M'Coy*	34	—	—
Anodontopsis, sp.	—	—	33
Avicula ampliata, *Phil.*	8	—	—
Avicula Danbyi, *M'Coy*	34	—	—
Cardiola interrupta, *Sow.*	11	—	10, 33
Cardiola striata, *Sow.*	15, 17, 16	—	—

* Recorded on the authority of Mr. J. E. Lee in the "Note-book of an Amateur Geologist." 8vo., London, 1881, p. 64.

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——	Ludlow Beds.	Wenlock Limestone.	Wenlock Shale.
Ctenodonta anglica, *d'Orb.* [*Nucula ovalis*]	29	—	—
Ctenodonta [*Nucula*] sulcata, *His.*	—	—	2, 33
Ctenodonta, sp.	—	—	34
Cucullella [*Cleidophorus*] antiqua, *Sow.*	2, 16, 29, 32	—	—
Cucullella [*Cleidophorus*] Cawdori, *Sow.*	22, 15	—	—
Cucullella [*Cleidophorus*] ovata, *Sow.*	29	—	—
Cucullella, sp.	—	—	34
Goniophora cymbæformis, *Sow.*	16, 29, 32	—	10
Grammysia [*Orthonota*] cingulata, *His.*	11, 15, 16	—	2
Modiolopsis [*Mytilus*] complanata, *Sow.*	11, 16, 32	—	2
Modiolopsis [*Mytilus*] gradata, *Salt.*	2 ? 8	—	2, 33, 34
Modiolopsis, sp.	—	—	33
Mytilus chemungensis, *Conr.*	—	—	2
Mytilus mytilimeris, ? *Conr.*	—	—	10, 34
Mytilus ? unguiculatus, *Salt.*	—	—	2
Orthonota amygdalina, *Sow.*	16, 17, 22, 29	8	—
Orth. angulifera, *M'Coy*	34	—	—
Orth. impressa, *Sow.*	16, 29	—	—
Orth. rotundata, *Sow.*	17	—	—
Orth. solenoides, *Sow.*	—	—	2
Palæarca, sp.	—	—	33
Pterinea [*Avicula*] lineata, *Goldf.*	6, 8, 11, 15, 29, 32	25, 27	2, 10
Pterinea mira, ? *Barr.*	—	—	33
Pterinea [*Avicula?*] planulata, *Conr.*	15, 22	—	2, 10
Pterinea posidoniæformis, *M'Coy*	—	—	33
Pterinea [*Avicula*] rectangularis, *Sow.*	32	—	—
Pterinea [*Avicula*] retroflexa, *Wahl.*	1, 8, 11, 15, 16, 29, 32	25, 34 Pen-y-lan	2, 10
Pterinea Sowerbyi, *M'Coy* [*Avicula reticulata*]	15	—	—
Pterinea, sp.	34	34	33
Gasteropoda.			
Bellerophon carinatus, *Sow.*	32	—	—
Bellerophon dilatatus, *Sow.*	15	—	—
Bellerophon Murchisoni, *d'Orb.*	32	—	—
Bellerophon trilobatus, *Sow.*	34	—	—
Bellerophon, sp.	—	—	10
Ecculiomphalus [*Cyrtolites*] lævis, *Sow.*	12	—	10
Eunema [*Turbo*] cirrhosa, *Sow.*	17	—	—
Euomphalus alatus, *His.*	—	—	10, 34
Euomphalus funatus, *Sow.*	15, 16, 29	—	—
Euomphalus sculptus, *Sow.*	15	27	—

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—	Ludlow Beds.	Wenlock Limestone.	Wenlock Shale.
Holopella [*Turritella*] gregaria, *Sow.*	29	—	—
Holopella [*Turritella*] obsoleta, *Sow.*	15, 29, 32	—	—
Loxonema sinuosa, *Sow.*	15	8	10
Loxonema sp.	—	—	34
Murchisonia articulata, *Sow.*	16	—	—
Murchisonia cingulata, *His.* sp.	15	—	—
Murchisonia [*Turbo*] corali, *Sow.*	29 32, 15	—	—
Murchisonia [*Pleurotomaria*] Lloydi, *Sow.*	15, 16, 29	—	—
Platyceras (*Acroculia*) haliotis, *Sow.* [*Nerita haliotis*]	16	—	3, 12
Pteropoda ?.			
Conularia sp.	—	—	34
Hyolites [*Theca*] Forbesi, *Sharpe*	8, 32	—	—
Tentaculites annulatus, *Schloth.*	—	8	—
Tentaculites ornatus ?, *Sow.*	11, 15, 29	—	2
Tentaculites tenuis, *Sow.*	32	—	—
CEPHALOPODA—			
Actinoceras subconicum, *d'Orb.* [*Orthoceras conicum*]	32, B. 34	—	—
Actinoceras nummularium, ? *Sow.*	F. 34	—	—
Cyrtoceras (*Meloceras*) compressum, *Sow.*	B. 34	—	—
Cyrtoceras (*Meloceras*) isca, *Blake*	—	B. 33	—
Cyrtoceras magnum, *Blake*	—	Wenlock of Pen-y-lan, B.	—
Cyrtoceras (*Meloceras*) quasirectum, var. contrarium, *Barr.*	—	B. 34	B. 34
Gomphoceras (*Tetrameroceras*) Deshayesi, *Barr.* (*Gomph. eta, Blake*)	B. 34	—	
Gomphoceras (*Tetrameroceras*) obovatum, *Blake*	B. 33	—	—
Gomphoceras gratum, *Barr*	B. 34	—	—
Gomphoceras imbricatum, *Barr.* (*Phragmoceras imbricatum, Blake*)	B. 33	—	—
Gomphoceras ventricosum, *Sow.*	F. 33 (Ludlow Beds ?)	—	—
Lituites ? ibex, *Sow*	16, 18, 29	—	—
Nautilus quadrans, *Blake*	—	—	B. 34
Orthoceras annulatum, *Sow.*	—	33, 34 Pen-y-lan B. 34 B. Cardiff	—
Orth. annulatum, *Sow.* var. fimbriatum, *Salt.* (*Orth. fimbriatum. Blake*)	—	34	—

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——	Ludlow Beds.	Wenlock Limestone.	Wenlock Shale.
Orth. annulatum, Sow., var. perundosum, *Foord.*	—	—	F. 33
Orth. arcuatum, *Sow.*	—	Pen-y-lan	—
Orthoceras Bacchus, *Blake* (?=*O. Bacchus, Barr.*)	—	—	B. 34
Orth. bullatum, *Sow.*	17, 32. B. 34	33. B. 34	B. 34
Orth. canaliculatum, *Sow.*	F. 34	—	—
" " var. spectandum, *Blake*	—	—	F. 33
Orth. Duponti, *Barr.*	—	34	—
Orth. elongatocinctum, *Portl.*	—	33	—
Orth. fretum, *Blake*	B. 34	—	—
Orth. gregarium, *Sow.*	—	—	B. 34
Orth. ibex, *Sow.*	16, 29, 32. B. 34. F. Llandegoeth.	—	—
Orth. imbricatum, *Wahl.*	15. B. 34.	—	—
Orth. kendalense, *Blake*	B. 34	—	—
Orth. ludense, *Sow.*	B. 34	—	—
Orth. Maclareni, *Salt.*	F. 34	—	—
Orth. mocktreense, *Sow.*	B. 34	—	—
Orth. nicholianum, *Blake*	B. 34	—	—
Orth. perversum, ? *Blake* [*O. imbricatum*]	15	—	—
Orth. recticinctum, *Blake*	—	B. 34	—
Orth. semipartitum, *Sow.*	32, B. 34	—	—
Orth. subannulare, *Münst.*	—	—	B. 34
Orth. subundulatum, *Portl.*	—	—	B. 34
Orth. tenuiannulatum, *M'Coy*	B. 34	—	—
Orth. tracheale, *Sow.*	32, 29. B. 34	—	—
Orth. truncatum, *Barr.*	B. 34	—	—
Orth. virgatum, *Sow.* [*O. angulatum, Phil. & Salt.* non *O. angulatum, His.* sp.]	15, 16, 27, B. 33, B 34, B. Pen-y-lan.	—	10 B. Pen-y-lan
Trochoceras giganteum, *Sow.* sp. [=*Lituites giganteus*]	B. 34, 15, and Cardiff.	—	10
Trochoceras gyrans, *Blake*	—	B. 34	
Troch. striatum, *Blake*	—		10. B. 33
Trochoceras sp.	—	34	—

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CHAPTER III

OLD RED SANDSTONE.

This formation may be grouped broadly in two perfectly conformable subdivisions, namely, an upper mass of red sandstones grits and quartz-conglomerates with subordinate marls, and a lower mass of marls with subordinate sandstones. In this part of South Wales, however, the quartz-conglomerates cluster so thickly in the upper part of the formation that they also merit distinction upon the map, though they dwindle away in parts of Brecknock. As a base to the Old Red Sandstone there occurs around much of the Usk Silurian inlier a grey or reddish quartz-grit, speckled with decomposed felspar, which differs both from the sandstones in the marl and from those in the Ludlow mudstones below. Though well developed near Llandegveth and Pontymoil the rock seems to be impersistent, and has not been separately mapped. The local subdivision of the Old Red Sandstone thus becomes threefold, namely:—

1. An upper subdivision about 200 ft. thick, consisting of yellow and red sandstones above, which pass up into the Carboniferous Limestone; and of quartz-grits and conglomerates below, the latter containing such multitudes of quartz-pebbles as to resemble shingle-beaches.
2. A series, about 500 ft. thick, but expanding northwards, of red, brown, and grey sandstones and grits, to which are principally due the bold escarpments of Monmouthshire and Brecknock. Marls and even thin limestones are not absent, and the series graduates down into
3. A mass, about 2,800 ft. thick, of red and mottled marls, with irregular bands of highly micaceous red sandstone and occasional conglomerates. In these marls occur the greater number of the concretionary inorganic limestones or cornstones, which form a familiar feature in other formations of the Old Red type. Downwards the series graduates into the speckly grit referred to above.

In making these three subdivisions, we do not suggest a precise correlation with the Upper, Middle, and Lower Old Red Sandstone of other parts of the British Isles. So far as our field-work has gone at present, we have found no break in the series from top to bottom, and it is on fossil-evidence only that we infer that the series includes representatives of both the highest and the lowest Old Red strata of other parts of the British Isles. The evidence, which, though meagre, is conclusive, will be found at the end of this chapter.

The thicknesses assigned to the three subdivisions have been obtained by plotting a section parallel to the Rhymney Railway, from the base of the formation at Cefn-coed-fach in Roath Park (Sheet

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263) to the Millstone Grit of Gwern-ddu. The section started in a thin, coarse, red grit and micaceous sandstone, which constitutes the base of the formation, and then passed over red and mottled marls, occasionally containing large scattered grains of quartz, and interstratified with deep-red micaceous sandstones. At Llanishen Station, 2,550 yards from Cefn-coed-fach, it crossed the outcrop of a gravelly red conglomerate. This band dips gently northwards, and with an average dip of 15° over the total distance of 2,550 yards, must lie about 2,000 feet above the base of the Old Red Sandstone. From Llanishen Station northwards the section traversed a shallow syncline, followed by an anticline, which is crossed by the railway in Wern-fawr; to the north of the anticline, at the entrance to the tunnel, conglomerates appear in force, apparently on the same horizon as those of Llanishen Station. From these conglomerates to the base of the red sandstones there is room for about 800 feet of strata, which makes up the total estimated thickness of 2,800 feet for the marls. The section then crossed the escarpment of the red sandstones and Carboniferous Limestone, where exposures are numerous, and gave the thickness of 200 and 500 feet for the conglomerates and red sandstones respectively.

These measurements have been made along the line followed by Prof. Sollas in 1879.* He then estimated the total thickness of the Old Red Sandstone to be 4,273 feet, but remarked that this was more likely to be an over- than an under-estimate. The result now obtained of 3,500 feet reduces his estimate by 773 feet, the difference being principally due to a gentler average dip being assigned to the outcrop of the marls than was supposed by him, but partly also to some strata formerly classed with the Old Red Sandstone having been proved to be Ludlow, and, therefore, have been excluded from the measurement.†

The quartz-grit which forms the basement-bed of the Old Red Sandstone has already been noticed in speaking of the boundary of the Ludlow Rocks between Llanddewi and Pontymoil (p. 7). At the cross-roads a quarter of a mile north of Trostra the grit contains quartz-pebbles up to half an inch in length and irregular fragments of what look like mudstone. South of Sluvad it is mottled and interstratified with deep-red shaly micaceous bands and with white shale, while a pit 600 yards south-west of Llandegveth Church shows hard grit interbedded with shaly sand and clay and yielded *Eukeraspis*.

The faulted tract of Old Red Sandstone occupied by Graigwith Wood yields but few sections. Grey grits with fragments of carbonised wood, associated with red marls and mottled shales which contain obscure plant-remains, are exposed in the brook east of the church. Northwards the basement-grit must be thin, for marl lies in close proximity to the Ludlow mudstones, while

* *Quart. Journ. Geol. Soc.*, vol. xxxv., p. 475, 1879.
† The strata alluded to crop out in Roath Park in Sheet 263.

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three small outliers of Old Red north and east of Graigwith consist almost wholly of marl, with a few small fragments of grit.

The east side of the Silurian inlier is bounded by what we may call the Llangibby Fault. All along it the Old Red Sandstone is vertical or highly inclined, and there is everywhere a doubt how much of the sequence is missing. A short distance from the fault the strata assume a general east south-easterly dip, which continues to Llanhennock and to the south side of the Usk, the frequent alternations of deep-red micaceous sandstones with red and mottled marls giving rise to a succession of strike-features. A limestone which was formerly burnt near Glen Usk must be high up in the marl sub-division, while some of the strata cropping out near Christchurch and Maindee must be very near its top; two bands of limestone have been worked in them at Coldra, and in one of the old pits in the lower band limestone is still visible to a depth of 3 ft., overlain by 4 ft. of purple marl with nodules of limestone.

The limestones of this formation are always impersistent, but tend to reappear at about the same horizon. It is not unlikely, therefore, that a band which has been quarried near Garth is the same as the Glen Usk bed, while the Garth band, though it is certainly not continuous, falls into the line of outcrop of a limestone which is intersected by a mineral railway near Malpas, and which has been quarried on the north side of the high road to Newport.* Similarly, the Coldra bands occupy about the same horizon as some thin limestones seen in the railway south-west of Newport.

The limestones, or "cornstones," alluded to above are compact, fine-grained, amorphous, and usually of a pale-red tint. They are devoid of organic remains, and, as has been already mentioned, are lenticular, their greatest horizontal extent rarely exceeding two miles, while they have not been seen to exceed 6ft. in thickness. The origin of such rocks has not been definitely determined, but they obviously have not resulted from the accumulation of microscopic organisms and shells, like some beds in the Lias or Carboniferous Limestone. It has been suggested that they may be a compacted sediment composed wholly of particles of carbonate of lime,† though no reason for the appearance of such sediments in the middle of the marls and sands is forthcoming; or, on the other hand, they may have been formed through the proportion of carbonate of lime in the Old Red waters have become locally excessive, and having been thrown down either chemically or by the action of vegetable organisms. This view of their origin receives support from the fact that the marls associated with the limestone are frequently crowded with concretionary nodules of limestone, as though the lime had been in excess but had insufficed to give rise to a solid bed.

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* The old quarries have been incorrectly identified as a Roman road.

† See on this subject Prof. W. J. Sollas, *Quart. Journ. Geol. Soc.*, vol. xxxv., p. 492, 1879.

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In addition to these bands of solid stone there are many conglomeratic "cornstones," or beds composed of more or less rolled lumps of amorphous carbonate of lime, imbedded with other materials in a calcareous matrix. Such beds seem to have originated in the deposit of a marl with calcareous concretions and in the subsequent washing away of the marl by some change of current, which failed however to carry away the concretions.

Returning to the Usk inlier, we find the Old Red Sandstone of its west side dipping a little north of west, and pass over in that direction a sequence similar to the one we have just traversed. Thus the lower or marl sub-division occupies the valley of the Afon Lwyd to near Pontypool; a limestone which crops out near Pont Newydd lies on the same horizon as an important band which runs continuously for nearly two miles near Pentre-bach, and this again seems to reappear near Sunnybank, between the Ebbw and Rhymney rivers, in the neighbourhood of Cefn Mably, and in the Rhymney Railway near the tunnel. An upper line of limestone-outcrops runs near the top of the marl-subdivision from near Pontypool, by Cwm-brân, between the Ebbw and the Rhymney, to Ruperra Park, where the stone was formerly much quarried. These two limestone-ranges correspond in horizon, and may be identical, with those of Glen Usk and Christchurch.

The upper conglomeratic and sandstone-subdivisions form steeply rising ground dominating the plain of red marl, but are confined to a narrow outcrop owing to their high inclination. Near Risca, however, where they roll over in a small syncline previously referred to, they extend upwards of a mile beyond their general range, while a similar local flexure brings up a small inlier of Old Red Sandstone near Machen.

The conglomerates which form the uppermost subdivision of the Old Red Sandstone are well shown in Pontypool Park, but become locally insignificant south of Pontypool. Near Machen and Rudry they are more strongly developed, and are particularly conspicuous in parts of Craig Llanishen, and thence westwards. Upwards they pass into soft sandstones, often yellow, interbedded with thin red marls, and so into the Carboniferous Limestone. Sections of these strata exposed near Upper Cwm-brân and Risca are mentioned on page 23.

The structure of the ground near Pontypool deserves a brief notice. The unusual narrowness of the Old Red outcrop is due principally to the disturbance which has already been described as having determined the south-eastern margin of the Coal Field. Around Panteg the red beds, reposing naturally upon the Ludlow, dip at no more than 10° to 18°, but in the cutting at Pontypool Road Station and in the field north of it the inclination ranges from 60° to 70°, while the river between the railway and the canal exposes red marls and flags with limestone-conglomerates partly dipping N.W. at 45°, partly vertical, and partly dipping to the S.E. at 70° to 80°, the last-named being probably due to an inversion. North of the canal the dip falls again to 30°, and in the Carboniferous Limestone to 15°. There is, therefore, a strong disturbance running close to the east side of Pontypool Road

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Station, and falling into the line of the fault which forms the north-western boundary of the Usk inlier (Sheet 232).

The existence of this disturbance precludes an accurate measurement of the Old Red Sandstone at this locality, but it may be noted that with an average dip of 10° there would be room for about 800 ft. of strata between the Silurian outcrop and the line of disturbance, and that with an average dip of 50° there would be room for about 2,000 ft. between the disturbance and the base of the red sandstones, making a total of 2,800 ft. for the marls without allowance for faults. The sandstones in Pontypool Park are about 900 ft., and the conglomerates 200 ft. to 300 ft. thick, giving a total for the whole Old Red Sandstone of something over 4,000 ft., as compared with 3,500 ft. near Cardiff.

The red marls are extensively used for making bricks, pipes, etc., near St. Julian's, north of Gold Tops, south of Malpas, and near Cwm-brân. Bands containing calcareous nodules are avoided as much as possible, and the marls are ground and worked up into shape without being left to temper.

Fossils of the Old Red Sandstone.

The following fossils have been recorded from the area included in this sheet of the map, with the exception of the *Archanodon* which occurred a short distance to the eastward. It is mentioned here, however, on account of the exceptional interest attaching to it.

Archanodon (Anodonta) Jukesi, W. H. Baily. In the *Quart. Journ. Geol. Soc.*, Vol. li., Proc. p. vii. (1895), the following passage occurs: "A specimen with *Anodonta* from the Lower Old Red Sandstone of Talgarth (Llanvaches), by Caerleon (Mon.), exhibited by Prof. H. G. Seeley, F.R.S., F.G.S., on behalf of Percy Hawkins, Esq."

Talgarth is situated on the Lower Limestone Shales, 5½ miles east of Caerleon, and half a mile W.N.W. of Llanvaches. This specimen, therefore, which undoubtedly came from the Old Red Sandstone, must have been obtained from the uppermost beds of that formation, that is from strata corresponding to the Kiltorcan beds of Ireland,* and the Tuedian group of Northumberland,† where alone it had been previously recorded.

The matrix is a somewhat coarse, friable, and ferruginous grit with much large mica, and is stated by Mr. A. S. Woodward to contain comminuted fish-remains. The block contains several internal moulds of the *Archanodon*, fairly well preserved without distortion, and showing the concentric lines of growth. Each cast measures about 5½ in. in length by about 2 in. in breadth. The specimen is now in the Geological Department of the British Museum, and is being described by Mr. R. B. Newton. ‡

* Memoirs of the Geological Survey of Ireland, Explanations of Sheets.

† *Nat. Hist. Trans., Northumberland and Durham*, vol. vii., p. 173.

‡ Since this paragraph was printed Mr. Newton's description of the fossil, with an account of all recorded occurrences of the *Archanodon*, has appeared in the *Geol. Mag.* for 1899, p. 245.

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Pteraspis rostrata, Psammosteus, and *Cephalaspis* have been obtained from Gold Tops, Newport, and *Pteraspis Crouchi* from Stow Hill Road, Newport, all by the late J. E. Lee. The same rock contained "apparently an abundance of comminuted vegetable remains."* Mr. Lee records also "*Scaphaspis* (*Pteraspis*) *Lewisi*" from Maindee, near Newport."† *Eukeraspis* has been obtained from the lowest band of the Old Red Sandstone during the resurvey, as already mentioned.

These fishes characterise the Lower Old Red Sandstone of other regions, and on the strength of their occurrence in the marl or lower sub-division of that formation in Monmouthshire, we are compelled to assume that the Lower Old Red Sandstone is represented wholly or in part by that sub-division. As already pointed out, we have found no break between these lower strata and the upper grits and conglomerates, the age of which is proved, not only by the fact of their passing up into the Carboniferous Limestone, but by their containing the *Archanodon* before mentioned. It would appear, therefore, that the great gap which is said to exist between the Upper and Lower Old Red Sandstones of Ireland and Scotland is filled up in South Wales, a fact of some significance when it is remembered how near South Wales lies to the region where the Devonian type sets in.

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* *Rep. British Assoc.* for 1879, pp. 332, 333. The Lee Collection is now in the Geological Department of the British Museum, and for further information concerning the specimens the reader is referred to the Catalogue of Fossil Fishes by Mr. A. S. Woodward, F.L.S., F.G.S.

† *Geol. Mag.*, Dec. 2, vol. ix., plate iii.

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CHAPTER IV.

CARBONIFEROUS.

Carboniferous Limestone.

This formation passes down conformably into the flaggy and generally yellow sandstones which form the top of the Old Red Sandstone, and not infrequently contains quartz-grains and even small pebbles at its base, as though the supply of such materials continued for a short time after the conditions for the formation of limestone had set in.

It is readily capable of a twofold sub-division, viz.:—

1. A main mass of limestone from 150 to 200 feet thick, but expanding greatly southwards and westwards, so as to reach 700 feet near Walnut Tree; it is generally brown and bituminous, but contains one or more bands of light-coloured oolite.
2. A lower sub-division corresponding to the Lower Limestone Shales of old authors, and consisting, in the upper part, of about 40 to 90 feet of shale, with thin bands and nodules of limestone, and in the lower part of brown, often oolitic, richly encrinital limestone, about 50 to 100 feet in thickness. This limestone is usually impure, and thence gets the name of "bastard limestone" among the quarrymen. Though the relative thickness of shale and limestone in the Lower Limestone Shales varies, the aggregate remains fairly constant at about 150 feet near Pontypool, and at about 300 feet west of the Rhymney.

The main limestone, with a band of white oolite eight feet thick, is worked in the westernmost quarry at Cwm Ynys-cou, and in the brook at the west end of the village is seen to pass up into a hard gannister sandstone belonging to the Millstone Grit. Close by to the east the lower limestone with a band of dark oolite has been quarried, while 300 yards to the south the intervening shales are laid bare to a depth of 50 feet. They contain nodules of ironstone with fish-remains.

From the quarries southwards for about five miles the strata dip at 70° to 80°, and the outcrops of the two limestones are indicated by little more than swallow-holes. There are quarries in the lower limestone, however, at Pen-yr-heol, Mountain Air, and in both rocks at Upper Cwm-brân. At the last-named place three quarries occur in line south of the Brick Works; the westernmost exposes the main limestone, a grey brown and blue argillaceous rock, with a two-foot band in its upper part contain-

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ing quartz-pebbles up to a half an inch in length; the middle quarry is in the lower limestone, a hard blue rock very sandy towards the base; the easternmost quarry is in almost the top beds of the Old Red Sandstone, and shows in descending order, deep-red marl, quartz-conglomerate about 5 feet thick, greenish cherty sandstone, and brown grit. The dip ranges from 70° in the lower to 90° in the upper quarry.

Half a mile southward there are two old quarries in the lower band, and at Llanderfil there is a small exposure of the overlying shale. Near the Henllys Colliery the lower limestone is exposed to a thickness of 40 feet, while 1000 yards further on there are old kilns both in this and the main bed, the pit in the latter showing a dark-blue argillaceous limestone generally in nodules. The nodules have been coated with a black material which seems to be a form of mineral pitch, and the bed gives egress to a chalybeate spring.

Through all this distance the main limestone forms no feature, either through having become quite thin, or more probably having been dissolved away at the outcrop. South-east of Twyn-barllwm, on the other hand, it forms conspicuous crags, and at Risca it is largely quarried, while in the same neighbourhood the lower limestone includes a massive oolitic rock (Plate, Fig. A),

On the west side of the Ebbw a railway-cutting shows that the upper part of the main limestone is a smooth-textured earthy rock upon which shales, the lower beds of the Millstone Grit, rest direct. Below this earthy rock comes a massive white limestone with a band of grit, exposed in a quarry north of Dan-y-graig, and this passes down into sandstone with quartz-pebbles and with calcareous encrinital bands, which, with some underlying shales, constitutes the upper part of the Lower Limestone Shales. The lower member of that sub-division is a massive limestone, so sandy as to weather into a current-bedded buff sand, which lies upon shales with nodular limestone; these strata are exposed at the north corner of the Chemical Works. The Old Red Sandstone, which follows next, is well shown in a brook 400 yards to the south, which descends over massive pebbly grit, alternations of red marl and sandstone, yellow laminated sandstone, and thick red sandstone in succession. The section forming Fig. 3, p. 39, passes 200 yards south of the Dan-y-graig quarry, and indicates the following thicknesses from the base of the Coal Measures downwards:—

Near Risca.

		Ft.
Millstone Grit—Sandstone and shale with coal (p. 28).		462
Carboniferous Limestone	Limestone	660
	Grit and shale	90
	Limestone	90

Old Red Sandstone.

The lower limestone forms the crag on which Castell Meredydd stands. It dips in a normal north-westerly direction, but at Machen it rolls over in a sharp little syncline, which can be located by an old limestone-quarry 150 yards north-east of the

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Church, by an exposure of Old Red Sandstone 100 yards north of the Church, by another of limestone in the railway, and by some old limestone-quarries 200 yards west of Ty-canol. The Old Red Sandstone thus forms an inlier along an anticline ranging nearly north-east; traces of the same anticline can be detected in the dips in the main limestone north of Draethen.

South of the Rhymney the lower limestone crops along the Draethen brook, but is locally insignificant; at Draethen the brook shows cherty limestone underlain by yellow and white clay and sand with calcareous bands, resting on yellow flags, while a bend of the Rhymney lays open sandstones, marls, and pebbly grits at a lower horizon. For the next mile the brook runs on the outcrop of these Upper Old Red strata and the lower limestone is either quite thin or absent. But at the Rudry Iron Mine that rock reappears, and thence westwards forms a conspicuous crag.

The iron-ore formerly worked at Rudry was obtained by driving a slope down the base of the main limestone, which had been locally converted into hæmatite; about 2,000 tons were got before or during 1875. Galena also has been worked in the main limestone north of Machen, on Cefn-pwll-du, near Draethen, and towards Rudry in a series of shallow shafts and open workings. The vein-stuff is barytes, sometimes containing doubly terminated crystals of quartz, as for example in a vein 200 yards west of Rhyd-y-gwern; the veins generally range east-north-east varying to east, but seem to be joints rather than faults, and have no persistence. Ore was being raised in 1850 and was washed in the Draethen brook near Cwm Glesyn. It is supposed to have been smelted at a furnace on the farm called Farm Furnace Blwm (see p. 47). Roman coins are said to have been discovered in an old lead-mine on Cefn-pwll-du.* The occurrence of galena in the Coal Measures of the neighbourhood is noted on pp. 46 and 51.

Much of the limestone of this neighbourhood is sandy, and at Rudry it contains interstratifications of mottled and yellow shale and sandstone in its upper part; on Cefn-on also the bulk of the sub-division consists of purplish and mottled limestone, with partings of shale or of smooth-textured blue argillaceous limestone. In its lower part, however, it is purer and more massive.

There are many exposures of the upper part of the Old Red Sandstone, and of the limestone nearly to its top, over the Rhymney Railway Tunnel, while a stream 600 yards further west gives a good view of some black shales with thin limestones which form the upper member of the Lower Limestone Shales. Trials for hæmatite, and apparently for lead, have been made in the base of the main limestone near the line of the tunnel, but without success.

The dip of the strata gradually increases in the ridge we are now following until it reaches 64° at Thornhill, but about a mile further on it falls to about 25° rather suddenly and with some

* *Archæologia*, vi., 18.

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small faults, at the same time that the outcrop correspondingly widens. Near Castell Coch the beds even roll over to the south and form a little syncline of the lower limestone, so as nearly to reproduce the structure noticed at Machen; Castell Coch, like Castell Meredydd, stands on a crag of the lower limestone, while the position of the syncline is fixed by a southerly dip in a quarry west of Castle Farm and by a northerly dip south of Tongwynlais Mill.

The main limestone of Fforest Fawr and Garth Wood has yielded much hæmatite. The ore occurred in the same form as in North Wales and Cumberland, namely, as an alteration-product, the limestone having been irregularly replaced by carbonate of iron, subsequently converted into an oxide. In other districts, both in South Wales and elsewhere, this alteration shows an obvious connection with the present or past distribution of the Trias. We know that the Trias steadily overlaps all the Old Red Sandstone and Lower Carboniferous Rocks between Newport and Llantrisant until it comes to rest on Coal Measures, and we may reasonably suppose that at no distant date (geologically speaking) it extended over all those parts of the limestone where the ore occurs. Rudry and the other spots named above seem to have been among the last to have been freed by denudation from their Triassic covering.

The ore is seldom confined to a vein, but occupies irregular chambers, which have usually been widened out along a joint or bedding-plane or any other parting which would give passage to water. A chamber in the middle of Fforest Fawr, known as the Slide Pit, was reached by a cross-cut of 40 yards through limestone, and extended along a joint in a direction N. 16° E.; it was followed downwards towards the north, and was opened out to a width of 6 yards. Another great irregular chamber near the northern margin of the wood leads into three caves, which slant down with the bedding, while a gash-vein, from which hæmatite has been raised, runs up the hill 200 yards south of Walnut Tree Bridge.

The largest workings, however, occur to the west of the Taff, in Garth Wood, but are now abandoned and difficult of access. According to Mr. F. G. Evans,* the caverns when tapped in the mining operations were usually more or less full of water. The roof and sides were coated with splendid crystals of carbonate of lime, and the floor with large quantities of iron-ore and sometimes of ochre. The ironstone obtained from the solid rock was usually associated with silica, and the cavities in it were lined with large quartz-crystals, some of which enclosed a nodule or a needle-shaped crystal of sesquioxide of iron. The mining was originally conducted by sinking on the top of Garth Hill, but subsequently a level was driven from the northern foot

* *Trans. Cardiff Nat. Soc.*, vol. iii., p. 42. See also E. Wethered, *Geol. Mag.* for 1882, p. 522; S. Vivian. *Proc. South Wales Inst. Eng.*, vol. xiv., p. 164, 1884.: J. D. Kendall, "Iron Ores of Great Britain," *London*, 8*vo.*, 1893, pp. 43, 44, 136, 326; F. T. Howard, *Trans. Cardiff Nat. Soc.*, vol. xxvi. part 1, 1893–94.

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of the hill. The workings extended to a depth of 170 ft. below the level, and the largest cavern measured about 60 ft. by 24 ft. Mr. S. Vivian, in the paper mentioned, refers to the occurrence in quantity of ore of commercial value as being exceptional in this district. The line of chambers was thought by him to tend to follow the bedding and to run above a hard crystalline limestone, but though they run nearly east and west along the strike of the beds, they run vertically downwards, and not along the dip, which is here at about 35°. Similar ore has been found in smaller quantities at Pen-y-garn, and in one case, south-west of the village, as a flat, replacing a bed of limestone. In no case is there any apparent joint or fault governing the deposition of iron. It seems rather to have eaten its way downwards more or less along the bedding. In the upper part of the series of chambers the ore was more siliceous than in the lower, a rule which is said to hold good generally in the district. A brown hæmatite from the lowest workings gave 39·63 per cent. of metallic iron in the raw state, while a red hæmatite from the bottom of one of the pockets yielded 54 per cent. The Garth Mine was worked from about the year 1800 to 1885, and in the last fifty years yielded about 1,000,000 tons. An analysis of ore, possibly from this mine, is given in the Appendix, p. 91.

The richly encrinital lower limestone also has been locally altered into a hæmatite near Rhubina. Specimens may be obtained from the spoil-heap of a trial-level 500 yards north of the house; they are soft, have a bright-red streak, and when sliced are seen under the microscope to consist of vast numbers of the ossicles of crinoids with many polyzoa and some fragments of brachiopod shells. The crinoidal and polyzoonal structures have been replaced by opaque iron-oxide, but are embedded in a clear, coarsely-crystalline matrix, which generally consists of rhombs of a carbonate defined by a film of iron-oxide (Plate, Fig. B). The same rock in its unaltered form crops out 700 yards west of Rhubina. *Spirorbis* is stated by Mr. Storrie to occur in the Rhubina ore.*

Hæmatite has been worked also near Maen-llwyd, about two miles north-east of the Rhymney Railway-tunnel; it occurred as a "flat" at the bottom of the limestone, and dipped with the beds at a high angle northwards. The ore is stated by Mr. Adams to have yielded 40 to 50 per cent. of iron, but the mine was heavily watered.†

Another form of alteration undergone by the limestone is illustrated by the series of analyses which has been supplied by the kindness of Mr. F. T. Howard, F.G.S., and which will be found on p. 90. It will be seen that one end of the quarry near Walnut Tree Junction yields a rock containing so much as 31 per cent. of carbonate of magnesia, and therefore approaching in composition to a dolomite. This, like the alteration into hæmatite,

* *Trans. Cardiff Nat. Soc.*, vol. x., p. 73.
† *Trans. Cardiff Nat. Soc.*, vol. ii., p. 27.

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tends to follow certain beds in the limestone, but also accompanies faults. In its complete form it changes not only the composition but the structure of the rock, and obliterates the microscopic organisms,* except in the nodules or bands of chert, which remain unaffected.

MILLSTONE GRIT.

This sub-division, like the other members of the Carboniferous System, is poorly developed at the eastern end of the Coal Field, but expands westwards. Its most prominent band is a hard grit, generally containing quartz-pebbles, which lies below the lowest workable course of mine-ground, and which received the name of Farewell Rock from the old miners on that account. It forms conspicuous features in the Church Wood north of Pontypool, and is readily traced thence southwards for about four miles. The included pebbles range up to an inch in length, and it contains also many moulds of tree-trunks. Cropping out below it, in the side of the road to Crumlin, there is a coal, 19 inches thick, which repeatedly appears at about this horizon along the north crop and which is associated with shales and mine-ground closely resembling Coal Measures. The following section was obtained in the Twmpath Level:—

In the Millstone Grit near Pontypool.

	ft.	in.
Grey rock - - - - - - - - - - -		
Black shale - - - - - - - - - -	0	5
Fireclay - - - - - - - - - - -	1	6
Coal - - - - - - - - - - - -	1	7
Rock bottom - - - - - - - - - -		

Below the shales associated with this coal there usually occurs an impersistent grit, which, however, is absent over much of the district under description, although in neighbouring parts of South Wales it forms the most conspicuous member of the Millstone Grit. In its absence the Millstone Grit consists only of the Farewell Rock and of a mass of shales intervening between that rock and the limestone, and such seems to be the case at Upper Cwm Brân, for though the uppermost grit frequently makes its presence known, there is no sign of there being any hard rock between it and the limestone. At Llanderfil the whole Millstone Grit outcrop is represented by a narrow belt of swamp with little rock showing, and it was the custom of old miners to find the outcrop of the Pontypool Rock Vein (the Black or Ras Las Vein of other districts) by stepping 100 yards northwards from the top of the limestone.

At Risca both sandstones reappear, the upper or Farewell Rock in the south-eastern side of the old landslip occupied by the Coed-y-Daren, while the lower is evidenced by loose blocks of quartz-conglomerate along the top of the limestone. The Sun Vein, which runs between the two, is said to crop out in the Daren

* Some interesting examples of dolomitisation will be figured in the part of this Memoir descriptive of Abergavenny.

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Brick Works, and to have been proved at a depth of 20 yards in a shaft which was sunk on the crop of the Hard Vein in Coed-y-Daren, but the depth has probably been understated, for at the Van Colliery, near Caerphilly, the distance from the Hard Vein to the Sun Vein, measured at right angles to the bedding, was 70 yards. The Sun Vein probably corresponds to the coal seen in the Millstone Grit at Pontypool.

On the south side of the Ebbw the lower pebbly grit thins out again, and in or near the brick-pit, a few yards from the top of the limestone, the greater part of the following sequence is open to view, as shown in Fig. 3, p. 39:—

The Millstone Grit near Risca.

	Ft.	in.
Beds not seen, but consisting of flaggy sandstones and shales, about	120	0
Shale with a few thin stone-bands: used for brick-making	30	0
Sun Vein Coal, worked out, but said to have been at this spot	3	0
Fireclay	2	6
Shale with some rock-bands and a few courses of iron-stone: used for brick-making	30	0
Strata, chiefly shales, estimated at	276	6
Limestone (see p. 23)	—	
Total thickness of Millstone Grit	462	0

About a mile to the south the lower pebbly grit suddenly re-appears and forms a rocky eminence known as the Devil's Apronful; above it lie shales in which the outcrop of the Sun Vein can be traced by old workings. At the Bovil Colliery levels have been driven into the vein for a distance of 900 yards to the north-east without encountering any fault of consequence, the dip being N.W. at 16 ins. to the yard, and the coal about 2 ft. thick. South of the Rhymney the lower pebbly grit thins out again, and in several places shales can be seen within a few yards of the top of the limestone; the Sun Vein also becomes insignificant. The Millstone Grit, therefore, consists here merely of an upper mass of flaggy and pebbly grit, often very coarse and highly felspathic, and a lower mass of shales. This character it maintains for the remainder of the outcrop in the map under description.

It may be noted that the shales of the Millstone Grit usually yield a marine fauna allied to that of the limestone. Owing probably to lack of sections no fossils have been obtained from this area, beyond the drifted plant-remains which abound in the grits everywhere.

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CHAPTER V.

CARBONIFEROUS (*Continued*).

Coal Measures.

Though there is here, as elsewhere, a perfect conformity throughout the Coal Measures, yet they fall naturally into three main sub-divisions, differing not only in character and in their influence upon the scenery, but to a certain extent also in their fossil contents. The sub-division, however, is local, and adopted for the convenience of the map, and is not to be considered as correlative with the sub-division into Upper, Middle, and Lower Coal Measures of other fields. For this reason local names have been employed, and the use of such terms as Upper or Lower Coal Measures avoided. The threefold sub-division in South Wales is due, as in the Forest of Dean and Bristol Coal Fields, principally to the intercalation of a great mass of felspathic sandstone, known as Pennant Grit, in the middle of the productive measures. The measures thus group themselves into:—

1. An upper series of shales and sandstones, which occurs only as outliers in the deeper parts of the Coal Field, and which forms cultivated land. In this series there occur an impersistent seam of coal or "rider" and a few bands of ironstone, while at its base there runs the Mynyddislwyn vein, the most noted house-coal in South Wales, now, however, nearly worked out. The greatest thickness of measures above the Mynyddislwyn Vein in Monmouthshire rarely exceeds 300 feet, but we have no reason to doubt that a far greater thickness of supra-Pennant measures once existed, though the greater part of them has been removed by denundation.
2. The Pennant Grit, a highly felspathic massive grit with subordinate shales, which forms the *Mynydd* or characteristic moorland plateau of South Wales. No workable coals occur in the Pennant Grit of East Monmouthshire, but some thin and generally sulphury seams develop westwards, and become valuable west of the Taff. For the base of the Pennant series the well-known Red Ash or Tillery Vein serves conveniently. The thickness of the series ranges from about 800 feet at Tirpentwys, near Pontypool, to 980 feet in the Taff Valley, near Quaker's Yard (see Vertical Sections, Sheet 80.)
3. A lower series, consisting chiefly of shales, in which the principal seams of the coal-field occur, as well as most of the argillaceous ironstones, which were formerly worked in South Wales under the name of "mine." The outcrop of this series forms a narrow band along this south-eastern margin of the Coal Field, but widens out northward as the dip decreases. The seams are being followed year by year further under the area overlain by Pennant Grit, and yield the greater part of the coal raised in Monmouthshire. While less bituminous than

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the Mynyddislwyn or Tillery Veins, they contain more of that ingredient in this county than in Glamorganshire, and are regarded as intermediate between house-coals and smokeless steam-coals. The loss of the bituminous constituent both in a downward, and horizontally in a westward, direction is in accordance with a law which holds good throughout the South Wales Coal Field. The thickness of this lower or infra-Pennant series varies from about 850 ft. near Pontypool to about 1,600 ft. in the Taff Valley.

It will be noticed that the measures expand rapidly in a westward direction. The accompanying figure, made for the purpose of illustrating the change, has been prepared from the data given in Sheet 80 of the Vertical Sections, but as no one shaft penetrated the whole series it became necessary to piece several sections together. Thus the Pontypool column is made up from the section of the Gilfach pit with the Rhos Rider inserted at its proper level, while the lower part is taken from the shaft-section of the Tirpentwys Colliery. The height of the Mynyddislwyn Vein above the Tirpentwys shaft has been obtained by levelling up the flanks of Cefn Crib. The Taff Vale section is taken from Harris' Steam Navigation Colliery, an allowance of 54 yards, however, being made in the upper part for the Llanfabon Fault which was crossed by the shaft. The position of the Mynyddislwyn Vein was determined by levelling to a small outlier close to the colliery. The two columns are about nine miles apart, from which it may be calculated that the lower measures expand at the rate of 1 in 67. For further details the reader is referred to Sheet 80 Vertical Sections; which contains a number of shaft sections above and below the Pennant Grit, drawn to one scale, and arranged geographically with the Black Vein (Ras-las or Nine-foot Vein) as a datum-line.

The Lower or Steam-Coal Series along the South Crop.

The name of "steam-coal" has come into common use in the eastern part of the Coal Field in consequence of the coals, in one part or another, possessing just that proportion of bituminous matter to render them a good steam-raising but smokeless fuel. The name, however, is not generally distinctive of any one part of the Coal Measures, for, in accordance with the law referred to previously, all the seams in turn assume the character of steam-coal before they finally pass into the anthracitic condition.

The outcrop of the lower series is marked generally by the huge open excavations and heaps of shale left by the working of argillaceous ironstone or "mine." The "mine" occurred in continuous bands or "pins," and in nodules or "balls," and the excavations were known as "patchworks."* The ore was worked both in open pits and levels, and a number of the courses of "mine-ground" received distinctive names, and were identified over large areas. The coals were almost neglected, and the "vein" of an ironstone-miner was always a vein of ironstone and

* "Scouring," by means of a sudden rush of water from a reservoir, was employed to clear the mine-ground in the same way that "hushing" was used in the North of England to clear the lead-veins.

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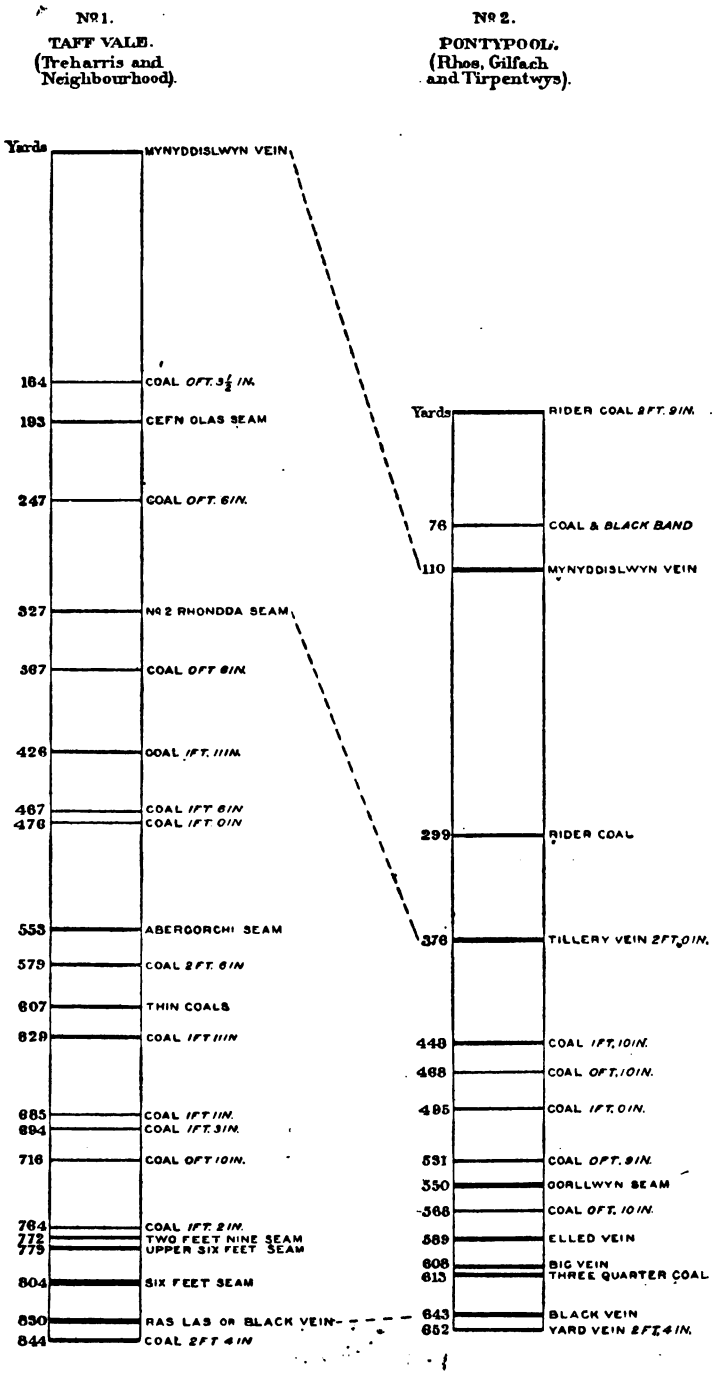

No 1 is 9 miles W11°S. of No 2

Figure 1.—Comparative Sections of the Coal Measures in the Taff Valley, and near Pontypool.

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not of coal: Hence came such names as Red Vein and Red Vein Coal. The ironstone is no longer worked.

At Pontypool these ores were raised in connection with the old Race Iron Works. The sections ran as follows:—

——	Cwm Llickey Pit.			Glyn Pit.		
	Yds.	Ft.	In.	Yds.	Ft.	In.
Measures with Soap Vein Mine ground	—	—	—	51	0	6
Soap Vein Coal	—	—	—	—	2	6
Measures with Black Pin Mine ground	40	2	4	35	0	10
New Vein or Elled Coal	—	1	0	1	1	0
Fireclay and shale with mine	3	1	0	14	1	6
Droideg or Big Coal	1	0	6	1	1	0
Shale, &c., with Black Band Mine*	15	1	0	11	2	0
Red Vein or Three-Quarter Coal	2	2	4	1	0	8
Shale with Rock Vein Balls	8	0	0	23	1	0
Rock or Black Vein Coal	2	1	0	2	2	0
Measures	8	0	0	5	0	0
Yard Vein Coal	—	2	6	—	2	6
Fireclay with mine	1	1	0	3	1	0
John Williams Coal	—	1	6	—	1	0
Rough sandstone	4	0	0	3	2	0
Shale with Meadow Vein Mine	3	0	0	3	0	0
Shale with balls of mine	7	1	0	8	1	0
Meadow Vein Coal	2	2	6	3	1	2
	101	2	8			
Hard white sandstone	—	—	—	4	1	0
Shale with mine	—	—	—	—	2	6
Old Coal	—	—	—	1	2	6
Hard white sandstone	—	—	—	7	0	0
Coal	—	—	—	—	—	5
Measures with Spotted Vein Mine-ground	—	—	—	3	2	10
Rough Coal	—	—	—	—	1	10
				189	2	9

The most important seam of coal is that known as the Rock or Black Vein. This becomes the Ras-las or Nine-Foot of the North Crop, and the Black Vein of the South Crop, and must not be confounded with the Rock Vein of Risca, or the Rock Fawr which corresponds to the Tillery Vein.

Rock [Black] Vein, Glyn Colliery.

Pant-y-gaseg.	ft.	in.	Lower Glyn Pond.	ft.	in.		ft.	in.
Shale	—		Shale	—			—	
Rubbish and Coal	1	7	Engine Coal	1	0	to	0	8
Coal	4	0	Coal	4	4	to	5	6
Coal	2	11	Parting	0	1	to	0	1
Do. inferior	1	4	Bottom Coal	3	4	to	2	9
			Soft Clod	—			—	

* A name applied to any ironstone which contains sufficient carbonaceous matter to support combustion.

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The Meadow Vein, which is being worked as a steam- and house-coal at Glyn, consists of the following bands:—

	——	Blaendare.	S.W. of Glyn.
		ft. in.	ft. in.
Meadow Vein	Top Coal	2 2	1 10
	Black clod	0 3½	4 9
	Middle Coal	4 4	4 10*
	Rashings	0 1	0 0
	Horn Coal (Cannel)	0 0	0 4
	Coal	1 2	1 8
	Rock	0 5	0 0
	Rough Coal	0 6	1 5
	Fireclay	1 2½	—
	Hard white sandstone	13 0	—
	Shale with two courses of mine	2 6	—
Old Coal	Top Coal	2 0	—
	Black clod	1 1	—
	Middle Coal	2 1	—
	Black clod	0 3	—
	Bottom Coal	0 6	—

The Rock (Black) Vein crops out 115 yards N.E. of the Glyn Pit, and near Waun-wern at Old Furnace. The Meadow Vein crops out at the Mountain Level, 100 yards N.W. of the reservoir at Upper Race, and can be seen on the north side of the road, 300 yards east of the crop of the Rock Vein near Waun-wern; it was proved at 133 yards 1 ft. depth in the Balance Pit. The Droideg crops along the upper railway of the Race Iron Works, and the New Vein is visible just above. The Soap Vein comes to the surface above Old Furnace, and the Black Pins were worked in the Gypsy Level and on both sides of the valley. The Old Coal is to be seen 100 yards east of the crop of the Meadow Vein near Waun-wern.

The crop-workings are now all disused, except for clay. In 1891 a fireclay, lying seven yards above the New Vein, was being worked in a level 300 yards N.N.E. of the Cwm-llickey Pits. Though six feet thick at Blaendare, it is only two feet at Glyn. The New Vein is worked here also.

The Tillery or Red Ash Vein was formerly visible at the base of a crag of massive Pennant in a quarry east of Blaendare Farm, and again in the Glyn Quarry, east of the Glyn Ponds. South of the ponds it is worked in an open level, but a gentle dip to the N.W. soon carries it below the bottom of the valley, so that it lies at 13 yards depth in a trial-shaft near the third mile-post from Pontypool. It varies in thickness from three feet to six inches.

On the north side of the Glyn Valley the outcrop of a coal-seam can be traced, at a height corresponding to that of the Tillery Vein on the south side, by a line of old workings. The seam is a rider, however, which lies about eighty yards above the Tillery

* Of which 1 ft. 3 in. is left for roof.

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Vein, and the fact of its occurring on a level with it is due to the Glyn Fault, which runs along the bottom of the valley with a down-throw north of about eighty-three yards.* A red tinge, or even sometimes a pronounced red colour, may be observed in some shales and clays below the Tillery Vein in this valley, and further north and east also. It seems to be proper to the beds, and not due to such staining as is commonly noticeable in strata which have been overspread by the Trias, for it is confined to one horizon, and does not affect the porous more than the impervious bands.

The Tillery Vein crops out about 45 yards above the top of the Glyn Pit, and therefore about 188 yards above the Black Vein (Vert. Sects., Sheet 80, Sect. 9). At the Tirpentwys Colliery (Sect. 10 of the same sheet) the Tillery Vein is shown as lying 267 yards above the Black Vein. The two pits being less than a quarter of a mile apart, so great a difference seems improbable, but discussion of the correlation must be reserved till the Risca sections have been considered (pp. 35 and 36).

The next colliery southward along the South Crop is at Cwm Brân. The "Main Slope" (mine-slope) marked on the six-inch map enters between the crops of the New or Elled Vein and the Black Pin Mine, and intersects the Black Vein at 500 yards distance. The principal level was commenced in the Old Red Sandstone, and driven through the Carboniferous Limestone and Millstone Grit, finally intersecting the Black Vein at a distance of 2,070 yards from the mouth. Thence it has been carried on in the Black Vein for a further 1,266 yards.

No section of the first part of this long level was obtainable, but in that part of it which followed the Black Vein the dip was found to be slightly south of west, with an average gradient of over 7° (1 in 7½) at first, but of less than 5° (1 in 11½) further west. At the outcrop the dip in the Coal Measures amounts to 45° (1 in 1), while the limestone is nearly vertical.

The section of the measures at Cwm Brân given in Vertical Sections, Sheet 80, Sect. No. 8, was obtained by Mr. James from measurements made in cross-measure drifts. It compares closely with that of the Glyn Pit, except that the Droideg Coal is only 1ft. 4in. thick instead of 4ft. The Rock (Black) Vein ranges from 5 to 6 feet in thickness of clean solid coal, and is used as a steam-coal, but would be suitable for blast-furnaces, coking or household purposes. The Meadow Vein is regarded as a second-class steam-coal, and as unfit for blast-furnaces.

Meadow Vein, Cwm Brân.

	ft.	in.
Shale roof		
Top Coal	1	6
Rashings	0	4
Top Coal	0	7
Stone	0	2
Middle Coal	3	7
Stone holing, 4 inches; clay holing, 3 inches	0	7
Coal	0	6
Stone	0	1

* As was pointed out to me by Mr. D. J. Lougher.

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	ft.	in.
Bottom Coal	1	0
Common fireclay	0	6
Best fireclay	2	0
Common fireclay	1	0

The fireclay below the Meadow Vein, and to a less extent that below the Old Coal, is worked at Cwm Brân and Henllys.

Two miles south of Cwm Brân a slope has been driven in the crop of the Rock (Black) Vein. The dip gradually dimished from about 55° at the outcrop to 34° (1 in 1½) 200 yards westwards, and to 22° or 12° (1 in 2½ or 1 in 4½), 500 yards westwards. At this spot there are two seams known by the name of Rock Vein, for the Black Vein keeps its local Pontypool name of Rock Vein so far south as this, while a vein lying at the base of the Pennant and known for several miles in the South Crop as the Rock Vein or Rock Fawr is recognisable in the hillside above.* From the quarry at Blaendare, previously mentioned, as far as Blaen-brân, nothing is seen of the Rock Fawr, but thence southwards there are frequent signs of a thin coal associated with red clay and overlain by a massive grit which forms the dominant feature along the Pennant hills.

In the valley east of Twyn Barllwm several old levels have been made upon what is called the Rock Vein, chiefly for the extraction of fireclay for the Risca Brick Works, and the outcrop of the seam in the Ebbw Valley is determined by two levels, one on each side of the alluvial tract. It is open to question, however, whether this Rock Vein can be correlated with the Rock Fawr of the South Crop, while it is certainly much above the Rock (Black) Vein of Pontypool.

The identity of the Rock Fawr of the South Crop with the Tillery Vein has been generally accepted, and is borne out by the results of the mapping, for these seams each lie at the base of the Pennant crags of their respective neighbourhoods; but it would appear that what is called the Rock Vein in the Llanbradach, Risca, and Abercarn Collieries lies about 100 yards lower down. By reference to Sheet 80, Vertical Sections, it will be seen that the Tillery Vein lies 283 yards above the Black Vein at Abercarn, 288 yards above it at Celynen, and 267 yards above it at Tirpentwys, while at the Glyn Pit it is calculated to be 188 yards above that vein. Quite a different seam, to which the name of Rock or Charcoal Vein was given occurs in the Risca No. 1 shaft 172 yards above the Black Vein, in the Abercarn shaft 174 yards above it, and in the Celynen shaft 168 yards above it, while in the Tirpentwys section there is a seam 148 yards above the Black Vein, which may correspond. To these sections may be added that of the Cwm Carn shaft, which is not included in Sheet 80, Vertical Sections, but of which an abstract is here appended. In

* This section, as shown in Fig. 2 (p. 37), would seem to form an exception to the rule that the measures thicken westwards. The measures at Cwm Brân, however, are highly inclined, and it is probable that the softer strata have been much compressed. In view of this probability, and in consideration of the fact that the Cwm Brân Rock Vein lies at the base of the Pennant, it is correlated with the Tillery Vein or Rock Fawr and not with the Rock Vein of Abercarn.

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it the No. 2 Coal (Rock Vein of Risca and Abercarn Collieries) lies 150 yards above the Black Vein.

Cwm Carn Pit.

(Abstract.)

——	Thickness.			Depth from Surface.		
	yds.	ft.	in.	yds.	ft.	in.
Glacial Deposits { Sand and gravel	9	2	0	—		
Glacial Deposits { Clay, gravel and stones	12	2	0	—		
Glacial Deposits { Sand	3	0	0	—		
Measures	11	2	11	—		
No. 1 Coal		2	2	38	0	1
Measures with conglomerate and white rock in the lower part	35	2	11	—		
Coal		1	2	74	1	2
Measures	10	0	6	—		
No. 2 Coal [Rock Vein] *		2	6	85	1	2
Hard white rock and conglomerate	9	1	8	—		
Coal			6	95	0	4
Measures, chiefly sandstone	19	0	4	—		
Coal			5	114	1	1
Measures, chiefly clift	15	1	2	—		
Coal			7	129	2	10
Rock and clift	13	0	3	—		
Coal			4	143	0	5
Measures	43	0	0	—		
Cannel Coal			8	—		
No. 3 Coal [Elled or New Vein]	1	2	4	188	0	5
Measures	5	2	6	—		
No. 4 Coal [Droideg Vein]		2	9	194	2	8
Clift	3	2	10	—		
Coal			4	198	2	10
Rashings, shale, and fireclay	1	1	9	—		
No. 5 Coal		2	0	201	0	7
Fireclay and clift with mine	31	1	0	—		
No. 6 Coal [Black or Rock Vein of Pontypool]	2	2	3	235	0	10
Soft holing		1	3	—		
Coal			7	235	2	8
Fireclay	1	0	5	—		
No. 7 Coal [Yard Vein]		2	2	237	2	3

It would appear, therefore, that if the Rock Fawr of the South Crop is the Tillery Vein, it cannot be the Rock Vein of these collieries. But, as already stated, the Rock Fawr occupies the same position relatively to the Pennant grit as the Tillery vein, and in addition the Tillery Vein throughout all the shafts named above has red and blue cliff a few yards below it, as is the case along its outcrop near Pontypool. The occurrence of red beds in the South Wales Coal Measures is unusual, and renders this a somewhat marked horizon. It must be assumed, therefore, that the Tillery and the Rock Fawr are one and the same vein, but that the Rock Fawr is not the Rock Vein of Risca, which appears to be a locally-developed seam some distance lower down. It may be remarked that at Llanbradach red and blue clift was

* Below this seam there was in the original section an entry of "sandstone rock 3 yds. 2 ft. 7 in., and coal 2 ft. 6 in.," which was said to be a repetition. These items are omitted in the abstract given herewith, and the depths from surface corrected accordingly

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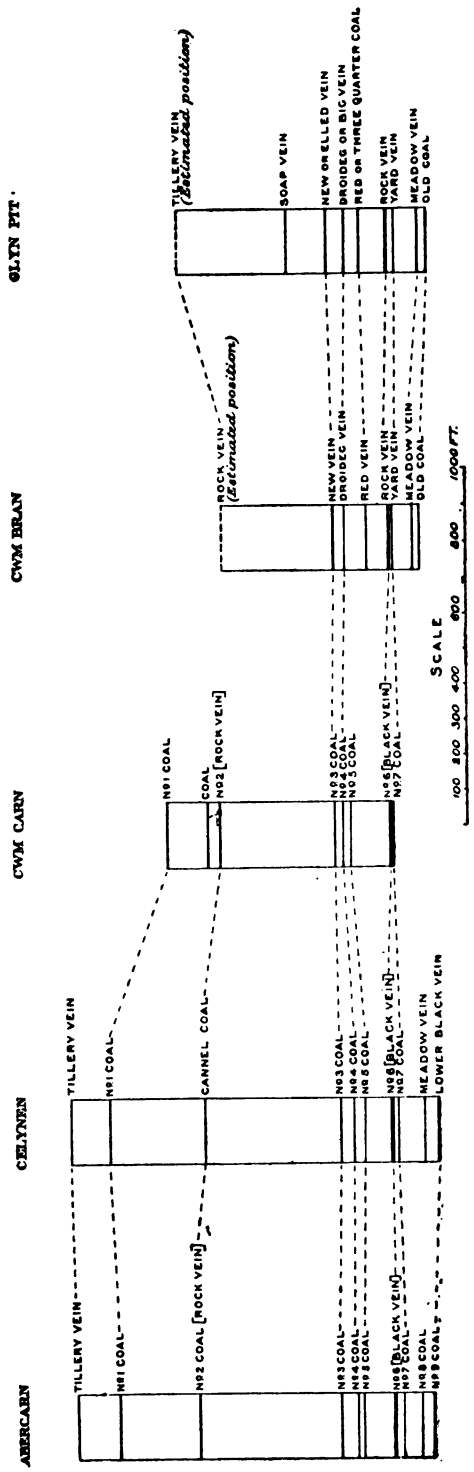

Figure 2.—Comparative Sections in the lower Measures between Abercarn and Pontypool.

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found at the proper distance above the Risca Rock Vein, though the Tillery Vein did not appear, unless as 5 in. of coal and rashings still further west, at the Albion Colliery, these red strata occurred a few yards below No. 2 Rhondda, which we take to be the equivalent of the Tillery Vein.

The accompanying figure gives a comparative view of the shafts referred to, and serves to illustrate the position and, to a great extent, the range of the Rock Vein of Risca. It shows also the position of a coal called No. 1 at Abercarn, Celynen, and Tirpentwys, but which is not identifiable elsewhere.

The following sections along the South Crop have been collected from old documents preserved at the various mines, and, failing these, from verbal information. They differ greatly, but it must be remembered that accurate measurements were difficult in highly-inclined and crushed strata, and that they were embodied upon rough and sketchy plans.

According to information supplied to Sir Henry De la Beche by Mr. Booker, and which had been apparently derived from Mr. Edward Jones of Rudry, there are two Rock Veins at Waunfawr, viz., the Upper Rock Vein 3 to 4 feet thick, and the Under Rock Vein 2 feet 10 inches thick, with 20 yards of rock between the two. The Under Rock Vein is further said to lie 170 yards above the Big Vein, which would nearly agree with the position of the Rock or Charcoal Vein of Risca and Abercarn. By the same authority the Black Vein is stated to lie 11 yards above the Brass Vein, the Brass Vein 44 yards above the Hard Vein, and the Hard Vein 90 yards above the Sun Vein, while two ironstones are referred to as being of excellent quality, viz., the Red Veins, in two beds 6 to 8 inches thick, 17 yards above the Red Vein Coal, and the Little Vein Ironstone below the Hard Vein; the latter, however, was proved at Machen and not at Waunfawr.

The distances given above do not agree either with those proved in the Risca No. 1 Pit, which was sunk through nearly horizontal strata, nor are they confirmed by such observations as can be made on the outcrops. A section, therefore, has been plotted through the Risca No. 1 Pit, the old Black Vein Pit, and the brick-pit in which the Sun Vein crops out, to the Old Red Sandstone near Long Bridge, and the following measurements vertical to the bedding deduced from it:—

Near Risca, Fig. 3.

		Yds.
From	Tillery Vein*	0
To	Rock or Charcoal Vein	94
,,	Red Vein	247
,,	Big Vein	254
,,	Black Vein	275
,,	Hard Vein	359
,,	Sun Vein	424
,	Top of limestone	527
,,	Top of grit and shale in the limestone	747
,,	Top of lower limestone	777
,,	Top of Old Red Sandstone	807

* This vein was just missed in the Risca No. 1 Pit, but the red and blue clift below it was recognised

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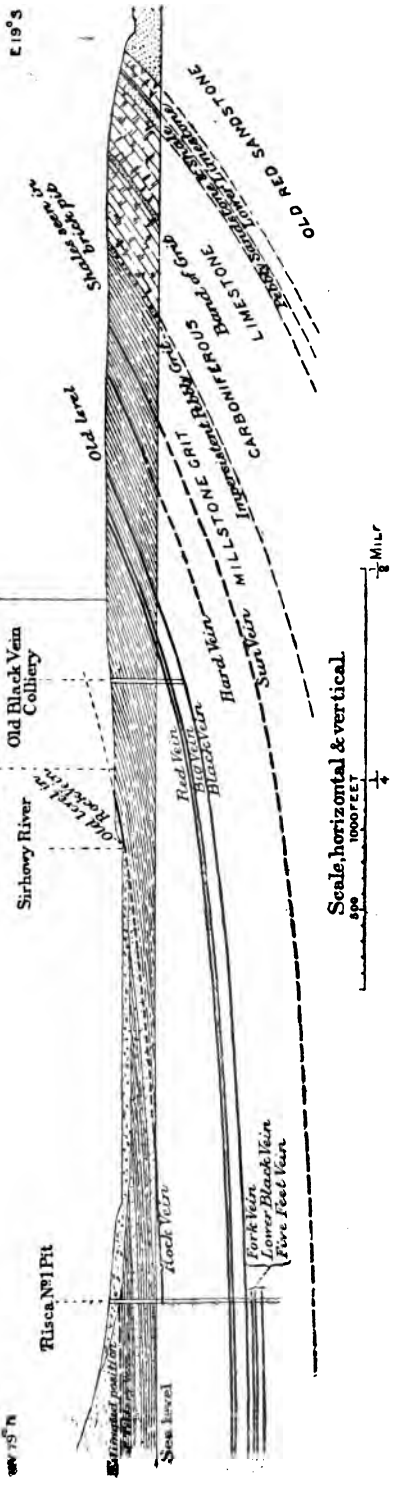

Figure 3.—Section from the Old Red Sandstone to the Pennant Grit, near Risca.

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At Daren, near Risca, the following section was supplied by the manager of the Brick Works. The measures are highly inclined and squeezed, and the coals are often absent or represented by lenticular masses only, though at times they are thicker than they should be.

Daren Colliery and Brick Works.

(Thicknesses given as vertical to the bedding.)

	ft.	in.
Red Vein Coal	1	8
Inferior clay	1	2
Grey Vein Coal	1	3
Clay	1	6
Big Vein Coal, as a lump only	4 or 5	0
Mixed coal and clay	9	0
Black Vein Coal: supposed to be 8ft., but absent here	0	0
Black Vein Bottom: mixed clay and coal	6	0
Rock	2	6
Mine-ground	4 or 5	0
Brass Vein Coal	1	2
Siliceous clay used in the brick works, usually	2	0
Rock, usually about 9ft., but here	33	0
Hard Vein Coal, usually about 1ft., but absent here	0	0
Hard Vein Clay, siliceous clay used in the brick-works	4 or 5	0

The measures between the Big and Black Veins and between the Black and Brass Veins are considerably thinner than elsewhere in the South Crop according to this information, but whether from local squeezing or faulting cannot be stated.

The Hard Vein is probably the Old Coal of Cwm Brân and Pontypool, but keeps the former name for some miles westwards. It lies either on or close to the top of the Millstone Grit.

At Machen, on the east bank of the Rhymney, the Sun Vein alone is being worked at the outcrop. On the west bank there are old adits near the crops of the Hard and Brass Veins, and an old slant by which the Black Vein was worked. The Rock Vein has been raised from under the alluvial flat northward and through the wood south-westward from the Machen Level. Its outcrop is marked by a long line of old slants and its roof of pebbly grit is conspicuous in many of the old mouths. It is said to have averaged 4 ft. 6 in. and even reached 6 ft. in thickness, but where it was visible in some slants near Rudry it did not exceed 3 ft. at the outcrop. It here becomes known as the Rock Fawr or Big Rock Vein to distinguish it from the Rock Fach which develops at Rudry from 20 to 30 yards above it. In addition to the slants mentioned above the Rock Fawr was worked by a cross-measure drift from the old furnace at Tyn-y-coedcae.

The Brass Vein Clay of Machen is said to have been 4 ft. thick in places, and to have made firebricks of good quality. It was improved by being mixed with some of the conglomeratic quartz-grit above the Rock Vein. The following analyses of the two rocks was furnished by the manager:—

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	Brass Vein Clay.	Rock Vein Conglomerate.
Silica	63·55	93·10
Alumina	24·75	2·65
Oxide of iron	3·56	3·97
Magnesia	0·63	0·28
Water	7·30	traces of
Phosphate of magnesia	0·21	copper
	100·00	100·00

In former years the Big Vein was extensively worked at Machen and presented the following section according to Mr. Forster Brown *:—

	ft.	in.
Roof, strong dark shale	0	0
Red Vein	1	4
Soft rubbish	0	10
Grey Vein Stone	0	7
Grey Vein Coal	1	4
Soft rubbish	2	0
Big Vein	8	0

The clod between the Red and Grey Veins is said to increase to 12 feet thickness at the Van Colliery; the Black Vein is 3 ft. 8 in. thick at Machen according to the same authority.

The following list of sinking distances at Rudry was obtained by Sir Henry De la Beche while he was engaged upon the original survey of South Wales. In the second column of the table the figures have been corrected for the dip which is sufficiently high to cause a serious discrepancy between the apparent and real thicknesses. The fourth column has been calculated from the data furnished by the Tir Jenkins Level, which are also quoted on p. 44 as given in the original.

Rudry Coal Measures.

(Communicated to Sir H. T. De la Beche by Mr. Booker.)

	Sinking Distance. Dip = 30°.	Thickness vertical to the Bedding.	Distance below Big Rock Vein, vertically to the Bedding.	Distance below Big Rock Vein, estimated from Measurements in the Tir Jenkins Level.
Coal, Little Rock Vein, or Pont-gwath yr harn		1 0 6	—	—
Clod	—	—	—	—
Blue rock or building stone	23 2 0	20 1 6	—	—
Clod	3 0 6	2 2 3	—	—

* *Proc. S. Wales Inst. Eng.*, vol. iv., p. 93.

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	Sinking Distance. Dip = 30°.	Thickness vertical to the Bedding.	Distance below Big Rock Vein, vertically to the Bedding.	Distance below Big Rock Vein, estimated from Measurements in the Tir Jenkins Level.
White rock	8 1 6	7 1 1	—	—
Coal, Big Rock Vein	1 1 8	1 1 0	0 0 0	0 0 0
Rock	1 2 9	1 2 0	—	—
White clod	2 1 0	2 0 1	—	—
Rock	3 0 0	2 1 10	—	—
Black clod	4 0 8	3 2 0	—	—
Black rock	3 0 6	2 2 3	—	—
Clift	2 2 6	2 1 4	—	—
White rock	2 0 0	1 2 2	—	—
Blue clod	0 0 8	0 0 7	—	—
Yellow rock	3 0 0	2 1 10	—	—
Coal, Rotten Vein	1 1 0	1 0 6	20 2 7	52 0 1
White clod	1 0 8	1 0 2	—	—
White rock	1 0 0	0 2 7	—	—
Blue clod	2 0 0	1 2 2	—	—
Pin of iron mine	0 0 3	0 0 3	—	—
Blue clod	2 2 10	2 1 5	—	—
White rock	3 1 0	2 2 8	—	—
Black clod	6 1 0	5 1 5	—	—
Coal Rider	0 0 9	0 0 8	35 1 11	—
Rock	2 3 4	2 2 1	—	—
Blue clod	0 1 0	0 0 10	—	—
Rock	4 0 0	3 1 5	—	—
Blue clift	7 2 0	6 1 11	—	—
Coal Rider	0 1 6	0 1 3	49 0 5	—
White clift	1 2 0	1 1 4	—	—
Rock	0 0 4	0 0 4	—	—
Coal Rider	0 1 4	0 1 2	51 0 3	—
Black clod	0 1 4	0 1 2	—	—
Coal Rider	0 0 4	0 0 4	51 1 9	—
Black clod	0 2 9	0 2 5	—	—
Coal Rider	0 0 8	0 0 7	52 1 9	—
Strong dark clift	1 0 8	1 0 2	—	—
Coal Rider	0 0 10	0 0 9	53 2 8	—
White rock	0 1 4	0 1 2	—	—
Blue clod	0 1 2	0 1 0	—	—
White rock	2 0 0	1 2 2	—	—
Soft clod	4 0 0	3 1 5	—	—
Spotted Pin Mine (say)	0 0 4	0 0 4	59 2 9	—
Blue clod	2 1 6	2 0 6	—	—
White rock	3 0 0	2 1 10	—	—
Clift	1 1 6	1 1 0	—	—
Big Vein Rock	2 1 6	2 0 6	—	—
White clod	2 0 8	1 2 9	—	—
Big Vein Balls of Mine (say)	0 1 0	0 0 10	—	—
White clift	3 2 0	3 0 6	—	—
Red Vein Coal	0 2 4	0 2 0	74 0 8	80 1 8
Big Vein Culm	1 2 6	1 1 9	—	—
Big Vein Coal	3 1 0	2 2 8	78 2 1	83 0 11

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	Sinking Distance. Dip = 30°.	Thickness vertical to the Bedding.	Distance below Big Rock Vein, vertically to the Bedding.	Distance below Big Rock Vein, estimated from Measurements in the Tir Jenkins Level.
Big Vein Clay	1 1 0	1 0 6	—	—
White rock	0 0 9	0 0 8	—	—
Blue clift	8 2 0	7 1 7	—	—
Black Ail [?] rubbish	0 0 3	0 0 3	87 2 1	—
Black Vein Mine (say)	0 0 10	0 0 9	—	—
Black clift	0 3 2	0 2 9	—	—
Black Vein Coal	1 1 6	1 1 0	90 0 7	102 1 8
Hard clift	15 0 6	13 0 5	—	—
Forked Vein Coal	1 1 0	1 0 6	104 1 6	122 0 11
Brown clod	2 2 0	2 0 11	—	—
Coal	1 0 6	1 0 2	107 2 7	—
Blue clod	2 2 0	2 0 11	—	—
Brass stone	0 0 6	0 0 5	—	—
Two courses and balls of mine	1 1 0	1 0 6	—	—
Soft clod	3 2 0	3 0 6	—	—
Brass Vein Coal	1 2 0	1 1 4	116 0 3	127 0 8
Clod	0 1 8	0 1 5	—	—
Fireclay	1 0 10	1 0 4	—	—
Hard blue clod	3 0 8	2 2 5	—	—
Pin of mine	0 0 4	0 0 4	—	—
Blue clift	1 2 6	1 1 9	—	—
Hard Vein Coal	0 2 4	0 2 0	122 2 6	132 2 9
Hard clift with balls of mine	9 2 6	8 1 7	—	—
Blue clod	1 2 6	1 1 9	—	—
Little Pin Mine (three courses)	1 0 0	0 2 7	—	—
Coal Rider	0 0 6	0 0 5	133 2 10	147 0 9
Sun Vein Rock	48 0 0	41 1 10	—	—
Clod	5 1 2	4 2 0	—	—
Sun Vein Coal	0 2 4	0 2 0	180 2 8	—
	245 1 6	214 0 0		

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Coals and ironstones traversed by the Tir Jenkins Level, Rudry measured by W. Llewellen in 1831.

(Communicated to Sir H. T. De la Beche by Mr. Booker.)

	Distance from Mouth of Level. Dip = 30°		
	Yds.	ft.	in.
Mouth of level	0	0	0
Big Rock Vein	25	1	6
Coal Rider, 1ft. 0in.	122	2	11
Coal Rider, 0ft. 7in.	126	0	9
Ground of Rotten Coal (coal does not prove)	129	1	7
Coal Rider 0ft. 6in.	131	2	2
Wraith Vein Mine	151	1	10
Red Vein Mine	180	0	5
Red Vein Coal, 0 to 4ft. 6in.	186	1	10
Big Vein Coal, 5ft. to 9ft.	192	0	4
Black Vein Balls	221	2	6
Black Vein Coal (coal does not prove)	230	1	10
Forked Vein Coal, 2ft. 9in.	270	0	5
Brass Vein Mine	273	1	3
Brass Vein Coal, coal 4ft. 2in., pyrites 0ft. 4in.	279	2	10
Hard Vein Coal, 2ft. 2in.	291	0	0
Little Veins	320	0	0

This section confirms, on the whole, the accuracy of the section of sinking distances given above, except in the case of the Rotten Vein, which however did not prove in the level, and may have been incorrectly placed. The deduced true thicknesses of strata are slightly greater throughout.

The following additional information respecting the Rudry measures was furnished by Mr. Aaron Johnson in 1892:—

Little Rock coal, a good house-coal	2	4
Poor coal	0	4
Band	0	4
Coal	0	4
Band	0	5
Coal	0	10
Hard ground, extending for 80 yards in cross-measure drifts, which, with the dip of 35°, indicates about 140 feet thickness,* probably about	120	0
Big Rock Vein, 2 feet at Rudry, 5 or 6 feet near Coed Cae, 4½ towards Machen	4	0
Strata, not all proved at Rudry (see next section)		
Pebbly conglomerate	2	0
Red Vein Coal	1	8
Stone	0	1½
Coal	0	6
Hard black shale or stone	1	3
Grey Coal	1	0
Soft blue clod	3	6

* In Mr. Booker's section, given above, the distance is stated to be about 92 feet, and at the Van Colliery (p. 46) it seems to be on 84 feet.

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Big Coal	Coal	2	9
	Parting	0	0
	Coal	0	8
	Parting	0	0
	Coal	2	0
	Band	0	3 to 8
	Bottom Coal	4	0
Clift and soft strata; not proved			
Black Vein		5	6
Mine-ground and clift—			
Fork Vein	Coal	1	6
	Band	1	0
	Coal	1	6
Strata; not proved			
Brass Vein		5	0
Fireclay, worked at Rudry		4	6
Clift			
Hard Vein		2	2
Hard Vein Clay; worked at Rudry		4	0
Mine-ground			

The Rock Vein is said to be particularly subject to "nips" in this neighbourhood. A small clod above it disappears, and the clod beneath it changes to stone; the coal at the same time thins away.*

A portion of the strata above the Red Vein noted in this section as "not all proved at Rudry" was traversed by the Rudry Shaft, of which an abstract follows:—

Rudry Shaft.

(Dip = 30°.)

	ft.	in.
Gravel	9	7
Shale with bands of rock	30	2
Fireclay	2	3
Rock	15	0
Fireclay	5	6
Clift	49	0
Coal (?Limog)	1	6
Mine-ground	63	8
Rock and clift	76	8
Big Vein Coal	11	2

Correction being made for the dip, the Big Vein must lie 121 ft. below the supposed Limog in a direction vertical to the bedding. The distance at Van Colliery (page 46) is given as 299 ft., and at Furnace Blwm as 160 ft., so that the identification of the Limog would appear to be doubtful. The Red Vein was not seen in the shaft, but came in about 200 yards west of it.

At the Van or Wernddu Colliery (Black Vein Colliery on the Ordnance Map) the two Rock Veins, the Red, Black, Fork, and Brass Veins have been worked. There are three shafts close together, and No. 1, the westernmost shaft, was sunk down to the Sun Vein at a depth of 440 yards. The measures were intersected also by Holmes's Level, the mouth of which lies 140 yards

* Forster Brown, *Proc. S. Wales Inst., Eng.*, vol. iv., p. 92.

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north of No. 3 shaft; the level reached the Little Rock Vein at 214 yards, and the Black Vein at 550 yards from the mouth. The thicknesses given in the following table have been calculated partly from the distances proved in the vertical sinkings, and partly from those in Holmes's Level and other cross-measure drifts, allowance having been made for the dip, which ranges from 30° to 38°. They are considerably greater than those given above for Rudry.

Van or Wernddu Colliery, Caerphilly.

—	Calculated thickness vertical to the bedding.	—	Calculated thickness vertical to the bedding.
	Yards.	Section contd.	Yards.
Little Rock Vein—		Big Vein—	
Measures - -	28	Measures - -	17
Big Rock Vein—		Black Vein—	
Measures - -	30	Measures - -	15
Bodwr Vein—		Fork Vein—	
Measures - -	17	Measures - -	10
Limog Vein—		Brass Vein—	
Measures - -	23	Measures - -	10
Yard Vein—		Hard Vein—	
Measures - -	71	Measures - -	70
Red Vein—		Sun Vein—	
Measures - -	5		
			296 (coals not included).

The best house-coals are the Little Rock and Bodwr, the best steam-coal is the Black Vein. In 1890 the Bodwr only was being worked. The best clays are associated with the Big, Limog, and Brass Veins; less good clays accompany the Little Limog and Hard Veins. According to Mr. Forster Brown, the Black Vein is 8 ft. thick, and the Brass Vein 4 ft. thick on the average, while the Fork Vein has a bad roof.* The Black Vein is said to crop out just inside the mouth of the Rhymney Railway tunnel, and the Big and Yard Veins just north of it. The wood south of the Van Colliery has been planted upon a labyrinth of ravines, which seem to have been formed by "scouring" the mine-ground (see page 30, Footnote). A fault in the western workings of the Van Colliery was noticed by Mr. Adams to be highly charged with lead-ore, but it was too narrow to be worth working.†

Some thin bands of quartz-grit, sometimes pebbly, are intercalated in the lower coal-series, as well as above the Rock

* *Proc. S. Wales Inst. Eng.*, vol. iv., p. 95.
† *Trans. Cardiff Nat. Soc.*, vol. ii., p. 37, 1870.

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Vein. One such bed crops out a few feet above the Big Vein in the Rhymney Railway cutting, and both to the east and west of it. Such grits are comparable to the rocks known as "Cockshots" in the Maesteg district, but they probably have a merely local development, and are of little value for purposes of correlation. Above the Big Vein Coal, on Caerphilly Common, there is a bold little scarp of felspathic sandstone, not distinguishable from Pennant, which, however, is of necessity included in the lower coal-series.

The Furnace Blwm Brick Works* are situated at the west end of Caerphilly Common; what was supposed to be a lead-smelting hearth was discovered at the Company's shaft on the Hard Vein (see also page 24). The best clay is below the Hard Vein and is 2 ft. 6 in. thick. It contains 68 per cent. of silica, and is used chiefly for glazed and sanitary ware. A clay below, which to the eye is indistinguishable and was formerly mixed in, was found to be injurious to the ware, and proved on analysis to contain only 16 per cent. of silica. The Brass Vein Clay is made into pipes, tiles, bricks, and terra-cotta. The Hard Vein Clay from Furnace Blwm is said to have been used at the Nant Garw Pottery, but it seems that it was a gannister above the Limog Coal that was in request, presumably for building the kilns.

The level now in use starts 50 yards south-west of Ty Melyn and intersects the following measures:—

Furnace Blwm Level.

(*Dip averaging about* 37°.)

	Distance from Mouth of Level.	Calculated Thickness Vertical to the Bedding.
	Yards.	Yds. ft. in.
Limog Fach Coal	60	0 0 10
do. Clay		2 0 0
Measures		16 0 0
Limog Fawr Coal	90	0 0 10
Measures		18 0 0
Tanner's Coal	120	0 1 2
Measures		30 0 0
Red Vein Coal (with a parting)	170	1 1 6
Measures		3 1 6
Big Vein (not profitable)	176	?
Measures		26 1 6
Wing Vein (not profitable)	220	?
Measures containing the Black Vein, about 3ft. 8in. thick, but not profitable		20 0 0
Brass Vein	253	1 1 0
Brass Vein Clay		2 0 0
Measures		14 0 0
Hard Vein	280	1 0 6

* For the information on this locality I was indebted to Mr. D. J. Rees Manager.

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The section differs from that of the Van Colliery in making the Limog Fach Coal 69½ instead of 99 yards above the Big Vein, and the Big Vein 62½ instead of 52 yards above the Hard Vein.

The Rock Veins have been worked up to Furnace Blwm from the Taff Valley, and the Wing, Fork, and Brass Vein have been raised from under the same ground, but the workings in the Hard Vein from Furnace Blwm westwards were stopped at the fault shown on the map, which seems to be a downthrow east of no great size.

The Rock Veins, with the grits and conglomerates associated with them, are conspicuous on the southern scarp of Craig-yr-allt. They have been worked extensively by levels close to the Walnut Tree Branch of the Rhymney Railway, but at the present time the clays and lower coals are more in request. The following details were furnished by Mr. William Davies, Manager to the Bryn Coch Brick Works, Taff's Well:—

Craig-yr-allt, Taff's Well.

		Ft.	In.
Rock.			
Bodwr or White Rock Vein, a house-coal		2	6
Measures (in cross-measure drifts 81 yards)	28	0	0
Rashings		1	3
Coal No. 3		1	3
Rashings		1	3
Fireclay, suitable for common bricks		4	0
Measures (in cross-measure drifts 25yds.)	10	0	0
Coal No. 2, a good house-coal		2	6
Fireclay of good quality		2	0
Measures (in cross measure drifts 23yds.)	9	0	0
Coal No. 1, a white-ash coal in beds (little worked)		3	0
Measures (in vertical sinkings 20 yards)	18	0	0
Limog Coal		1	8
Fireclay, inferior		1	6
Measures	7	0	0
Limog Fawr Coal (a bad roof of clod)		3	0
Measures	24	0	0
Yard Coal (good)		3	0

These are followed in descending order by the Black Vein, a good coal, 6 to 9 feet thick; the Wing Vein, said to be an excellent gas-coal, 4 feet thick; the Slaty Vein, a white-ash coal in three beds, each 1ft. 6in.; the Forky Vein, 3 to 4 feet; the Brass Vein, 4½ to 5 feet, with a good fireclay beneath it; the Hard Vein, 4 feet, with 3 feet of good fireclay beneath it.

The Brass Vein gains its name from the fact of its containing much iron-pyrites, and just under the coal there occurs a black bass, which used to be mixed with clay for brick-making, and is said to have been employed at Nant Garw; this stone also is rich in sulphur, and gave off powerful fumes when burning in the hillock. The water from the Brass Vein is said to have been always warm and powerfully corrosive. It is supposed to form the source of the warm spring known as Taffs' Well (p. 90).

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On the west side of the Taff the Rock Fawr is readily traced by the conglomerate roof and by a line of old slopes, but the Rock Fach is not distinguishable. It will be noticed that the crop along the south side of Garth Hill is far to the south of the crop on Craig-yr-allt, a fact which points to there being a large westerly downthrow along the Taff Valley. The same displacement is observable in the limestone also, though to a less degree in consequence of the high dip. The lower coals were worked on the south side of Garth for the Pentyrch Iron Works by levels at Pentyrch and three-quarters of a mile up the valley. Further west, at Poorhouses, a slope was being opened in 1890 in the crop of the Limog. The dip was N.3°W. at 50°, and four seams had been proved, namely, in descending order, Coal No. 2, 10 inches thick, cropping near the fork of the road; Coal No. 1, 8 inches thick, cropping 30 yards south of No. 2; the Little Limog, cropping 55 yards south of No. 2; and the Limog, said to be 4 feet 6 inches thick, cropping 68 yards south of No. 2. The Hard Vein crops 220 yards south of No. 2.

In Tyn-y-Coed there are some old patchworks in the mine-ground and some small crop-workings in some of the coals, but since the re-survey of the district a level has been driven through the series, with the intention of working the principal seams. The dip (at the outcrops) ranges from 75° or 80° in the Millstone Grit to 50° in the Rock Fawr. The whole series must formerly have been exposed to view in the Barry Railway cutting, but is now much obscured. Close along the west side of the railway there runs a large fault, with a downthrow west, which shifts the outcrops as much as 350 yards. This, with so high a dip, indicates a vertical displacement of nearly 300 yards. All the coals of this neighbourhood are bituminous, though the lower seams are less so than the upper.

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CHAPTER VI.

CARBONIFEROUS.—(*Continued.*)

COAL MEASURES.—(*Continued.*)

The Lower or Steam-Coal Series within the Coal Field.

In describing the measures of the interior of the Coal Field, it will be convenient to take the principal valleys in geographical order from east to west. With the exception of the Glyn Valley, which runs a little north of east, they run nearly north and south, and include the Glyn, with portions of the Ebbw, Sirhowy, Rhymney, Aber, and Taff Valleys.

The Glyn Valley.

The most important point to be noticed in this valley is the fault which has already been mentioned as throwing the strata down northwards about eighty-three yards, so as to bring the Tillery Rider on a level with the Tillery Vein (pp. 33, 34). The fault follows the bottom of the valley as far as the third milestone from Pontypool, where it crosses the mountain to Celynen. Its exact throw seems not to have been determined in the Glyn Colliery, but a barren strip is shown upon the plans in the Rock (Black) Vein, which falls into the line indicated. The Tirpentwys workings were supposed to be approaching the fault from the north in 1891, but had not reached it. The Black Vein lies 410 feet below Ordnance Datum at Tirpentwys, 294 feet above that Datum at the Glyn Pit, and 714 feet above it at Cwm Llickey (p. 32). The shaft-sections of the Glyn and Tirpentwys Collieries are given in Vertical Sections, Sheet 80.

The Ebbw Valley.

In the portion of the Ebbw Valley included in this sheet of the map there are situated the Risca, Abercarn, Celynen, and Llanhilleth Collieries, sections of all of which are given in Sheet 80. To these may be added Cwm Carn (p. 36), which was closed at the time of the resurvey. The Black Vein is the most extensively in demand, but the Lower Black Vein is also raised at Celynen, and one of the higher coals has been touched. The Tillery Vein is worked at Llanhilleth, but occasionally becomes too thin to be profitable. The Black Vein lies at the following depths below Ordnance Datum:—Cwm Carn, 181 feet; Risca, 575 feet; Abercarn, 562 feet; Celynen, 711 feet; Llanhilleth, 475 feet in the New Pit and 415 feet in the Old Pit on the other side of a twenty-yard fault. From these figures it would appear that Celynen is nearest to the bottom of the basin, but as a fact the workings from Celynen stop at a large fault of unknown throw, which is clearly the continuation of the Glyn Fault. West of Celynen the fault forms the boundary of the Mynyddislwyn outlier of upper measures, where it was known to old miners of the coal of that name as the Farewell Fault. The Glyn Fault

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being a downthrow north, the deepest part of the basin lies on the north side of it, and under the southern part of the Blackwood tract of upper measures. Within the tract the outcrop of the Mynyddislwyn coal gives a reliable clue to the depth to the lower productive measures, for to the east at Tirpentwys and to the west at Quaker's Yard the distance between the Mynyddislwyn and Black Veins has been determined (p. 31).

The Tillery Vein lies at a depth of 80½ yards in the Llanhilleth Shaft, 31 yards of which, however, are gravel and made ground. The Tillery Rider, which lies 69 yards above the vein, is 1 ft. 4 in. thick, and crops out in the east side of the tramway by the old pit, where there are two old levels in it. A new shaft which was being sunk on the east side of the river in 1891 commences in the Rider. The fault previously alluded to as running between the two pits is said to turn westwards by Royal Oak, and not to run, as might have been supposed by Swffryd-fach.

At Abercarn the Black Vein is the principal seam, though the Tillery also has been worked. The section has already been discussed. At this colliery a lead-vein was found "in a seam of bituminous coal in the Pennant Series." The lode was nearly vertical and contained shale and sandstone, calcspar and iron-pyrites, débris of coal mixed with calcspar and iron-pyrites and sulphide of lead, these materials being arranged roughly in layers parallel to the walls of the vein. The vein ran in a direction N. 20° E. (Magnetic 1859), and dipped north-west at 80°, but it was not followed for more than three feet above or below the coal, or about 20 feet altogether. It appears to have shifted the coal a few inches. In the same colliery a nearly vertical lode filled with iron-pyrites was found extending from the Charcoal Seam down for about 11 yards.*

A Black Band, or carbonaceous clay-ironstone, lying above the No. 2 or Charcoal Seam of Abercarn and Rock Vein of Risca, was formerly worked, and yielded the analysis given on p. 91.

The Sirhowy Valley.

The lower coals are worked at the Risca Pit, the Black Vein lying at a depth of 285 yards from the surface (Vert. Sections, Sheet 80, Section 14) or 575 ft. below Ordnance Datum. Thence for some miles up the valley they remain untouched, but in the year 1875 an attempt was made to reach them at Gelli-groes. The Mynyddislwyn Vein crops out in the hillside at Caer-llwyn at a height of about 800 ft. above the sea, and the shafts were commenced in the alluvial flat 400 ft. lower down. They were placed, however, on the north side of the Gelli-groes Fault, which seems to have been either unknown or ignored, with the result that at 80 yards depth they intersected the Mynyddislwyn Vein and were abandoned.

A small seam of local development only was being opened in 1892 on Twyn-yr-Oerfel, 1¼ miles west of Nine Mile Point, and another about 75 yards lower down had been tried a little and

* E. Rogers, *Trans. South Wales Inst. Eng.*, vol. i., p. 228.

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could be traced for about a mile. These coals occur high up in the Pennant, and, as usual in such a position, contain much pyrites. They may correspond to the Coed Cae-dyrys and Stinking Veins of the Taff Valley. (See also pp. 66, 67).

The fault which crosses the Sirhowy Valley a quarter of a mile below Nine Mile Point has not been fully proved. It is popularly supposed to be the Pengam Fault, a well-known downthrow south-west of 66 yards in the Mynyddislwyn Seam at Fleur-de-lis. At Caer-llwyn there must be a fault to account for the outlier of that coal, and under the ravine east of Pen-y-Trwyn a south-westerly downthrow has been touched in the Black Vein workings from Risca. In the same line, but on the south side of the Sirhowy these workings extend up to, but not beyond, a fault which was supposed to be a downthrow of over 100 yards, and it has been estimated from the difference in level between the Rock Vein workings at Risca and Machen that there must be a westerly downthrow of 200 yards between the two.* But no fault can be detected in the crops of the Rock Vein, Millstone Grit and Limestone a little further south and it seems probable that the throw of the fault near Risca has been much overestimated, the difference in level alluded to being accounted for by a strong westerly dip which marks the commencement of Caerphilly syncline.

The Rhymney Valley.

This valley leaves the Coal Field at Machen, where the crop-workings have already been noted. Northwards the seams dip at a high angle under the Caerphilly syncline, in which they have not been touched, but beyond the syncline they rise at a gentle angle northwards to the Pontypridd anticline, one of the most important structural features in the Coal Field.

The anticline commences between the Sirhowy and Rhymney Valleys as a broad gentle roll; it crosses the latter a few yards south of Taren-y-Morthwyl, and passes thence by the head of the Aber Valley to Pentre-bach, near Pontypridd, still as a broad roll, gentle as compared with the steep uplift on the west side of the Taff. The Llanbradach Colliery, which was being sunk at the time of the resurvey, is situated a short distance south of the crest of the anticline. The Black Vein was reached at a depth of 520 yards (Vertical Sections, Sheet 80, Section 15) or 1,160 feet below Ordnance Datum.

Two important faults pass near Taren-y-Morthwyl. The Gelligroes Fault ranges N.E.—S.W., and is a downthrow north of unknown amount. It forms the boundary of the upper measures of Blackwood for nearly three miles, and is visible in a quarry 450 yards north of Tyle-gwyn, but cannot be traced down the eastern slope of the Rhymney Valley, though it ranges for the Coed-y-Daren, a crag just north of Taren-y-Morthwyl. The Llanfabon Fault, the second of the two referred to, crosses the Taff Bargoed near Treharris (pp. 57, 58), and runs thence close past

* T. Forster Brown, *Proc. S. Wales Inst. Eng.*, vol. iv., p. 96.

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the Park Quarries and Singrug, where it throws in the upper measures of Llancaiach. Its downthrow, which is 54 yards to the north-east at Treharris, is reputed to amount here to 140 yards. From Llancaiach it is easily traceable to the Rhymney Valley at Ystrad Mynach. Though its exact position in the valley is obscured by gravel there can be little doubt that it divides the outlying mass of Mynydd Dimlaith from Mynydd Grug, east of the valley, and that it is the same fault which throws the Mynyddislwyn Vein 45 yards down eastwards at Bedwas.

About half a mile north-east of the Llanfabon Fault runs the Gelligaer Fault, a downthrow in the opposite direction of 100 yards, the two thus producing a trough. The position of the Gelligaer Fault, however, is uncertain south of Penalltau, nor can it be fixed on the east side of the Rhymney.

On the north side of this trough the measures continue to descend gently northwards until the Mynyddislwyn crop comes down to the bed of the river. In a short distance, however, they reach their lowest point, and from Pengam northwards they rise equally steadily, so that some shafts recently sunk by the Rhymney Iron Company one mile south of Bargoed commenced below the Mynyddislwyn Vein and reached the Brithdir (Tillery) Vein at 285 yards depth, or 285 ft. below Ordnance Datum. The Mynyddislwyn Vein crops out about 500 yards west of the pits, and seems to lie about 342 yards above the Brithdir Vein. At Harris' Navigation, the No. 2 Rhondda (Tillery) Vein lay at 240 yards depth. Allowing 54 yards for the Llanfabon Fault and 33 yards for the height of the Mynyddislwyn crop above the shaft, we get 327 yards as the distance between the two seams at that colliery.

The Brithdir Vein has been worked also between the Rhymney and the Bargoed-Rhymney rivers, the Daren Pit on the latter having reached it at 110 yards depth, or 390 ft. above the Ordnance Datum. The difference in level of the seam from the Rhymney Iron Co.'s pits to the Daren Pit thus amounts to 675 ft., which in a distance of $2\frac{1}{8}$ miles indicates an average rise of 1 in $16\frac{1}{2}$.

The Aber Valley.

This valley takes its rise in the Pontypridd anticline on the south side of Mynydd Eglwysilan, and runs thence down a dip-slope of Pennant into the Caerphilly Basin, where it joins the Rhymney. Until 1893 no coal had been worked except the Mynyddislwyn at Old Furnace and some small veins in the Pennant near Senghenydd, at the head of the valley.

Of these Pennant seams, one exposed to view in an old level at Parc-mawr is 2 ft. 2 in. thick, and what appears to be the same seam has been worked in the wood south of Gwern-y-milwr, while south of Parc-newydd the shales associated with it have caused extensive land-slipping. The Parc-mawr seam lies about 612 yards above the Nine Feet Coal (Black Vein of the South Crop), and may therefore correspond to the Cefn-glas Seam of the Taff Valley (p. 58). On the eastern side of the Aber river

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an old level shows sandstone underlain by 18 ft. of shale, with streaks of coal and a seam 1 ft. thick.

In 1893 shafts were commenced at the head of the valley by the Universal Steam Coal Co., and yielded a section of which the following is an abstract*:—

Lancaster Pit, Aber Valley.

(Abstract of a Section communicated by Mr. W. Rees.)

	Thickness.			Depth from Surface.		
	Yds.	ft.	in.	Yds.	ft.	in.
Hard close ground, mixed with clay [Boulder Clay]	25	0	0	25	0	0
Measures, nearly all rock	132	1	6	157	1	6
Coal — ft. 0 in. 9						
Fireclay — 2 4						
Coal — 0 3	1	2	3	159	0	9
Fireclay — 1 8						
Coal — 0 3						
Measures, including some red and blue clift at 185 yards depth and some white rock	46	1	11	205	2	8
Coal — 0 10						
Rashings — 1 6	1	0	0	206	2	8
Coal — 0 8						
Measures, including some white rock and conglomerate	31	1	4	238	1	0
Coal — 0 6	0	0	6	238	1	6
Clift	13	2	8	252	0	10
Coal — 1 6						
Rashings — 0 4	0	2	7	253	0	5
Coal — 0 9						
Fireclay and clift	5	2	7	259	0	0
Coal — 1 6	0	1	6	259	1	6
Fireclay, rock, and clift	10	1	5	269	2	11
Coal — 1 2		1	2	270	1	1
Rock and clift	11	2	3	282	0	4
Coal — 1 6		1	6	282	1	10
Clift and about 25 yds. of rock below	40	2	2	323	1	0
Coal — 0 9			9	323	1	9
Fireclay and clift	15	0	3	338	2	0
Coal — 0 9			9	338	2	9
Rock and fireclay	2	0	11	341	0	8
Coal — 0 9						
Rashings — 0 3		1	5	341	2	1
Coal — 0 5						
Fireclay and clift	19	0	11	361	0	0
Coal — 1 3		1	3	361	1	3
Fireclay and clift	3	1	5	364	2	8
Coal — 0 6			6	365	0	2
Fireclay and clift	16	1	1	381	1	3
Coal — 1 0		1	0	381	2	3
Clift and rock	23	1	9	405	1	0
Coal — 0 11			11	405	1	11
Fireclay and very hard rock	16	1	8	422	0	7
Coal — 1 0		1	0	422	1	7
Fireclay and clift	3	1	6	426	0	1
Coal — 1 0		1	0	426	1	1
Fireclay and clift	4	2	6	431	0	7

* The sinking was completed too late for insertion of the section in Sheet 80, Vertical Sections.

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— —	ft.	in.	Thickness. Yds.	ft.	in.	Depth from surface. Yds.	ft.	in.
Coal	1	0						
Clod	0	2		1	7	431	2	2
Coal	0	5						
Fireclay and clift			6	0	10	438	0	0
Coal	0	7		0	7	438	0	7
Fireclay and clift			7	0	2	445	0	9
Coal	1	6		1	6	445	2	3
Clift and some rock			29	0	9	475	0	0
Coal	1	4						
Clod	2	0						
Coal	0	3	1	2	7	476	2	7
Rashings	1	6						
Coal	0	6						
Fireclay and hard black rock			6	1	11	483	1	6
Coal	0	4	0	0	4	483	1	10
Fireclay and clift with mine balls			3	0	6	486	2	4
Coal	1	0						
Clod	0	11						
Coal	0	6	1	1	2	488	0	6
Clod	0	1						
Coal	1	8						
Clift			5	1	6	493	2	0
Coal	1	4						
Clod	0	3	1	0	3	494	2	3
Coal	1							
Fireclay and clift with mine			11	1	2	506	0	5
Coal	1	6						
Parting	0	1						
Coal	1	5	2	1	4	508	1	9
Clod	1	2						
Coal	3	2						
Fireclay and clift			8	0	7	516	2	4
Coal	0	11	0	0	11	517	0	3
Fireclay and clift			10	2	2	527	2	5
Coal (probably the Four-Foot of Albion)			1	1	2	529	0	7
Fireclay and clift			4	2	0	533	2	7
Coal and clod alternating	3	6	1	2	5	535	2	0
Coal	1	11						
Clod and clift with mine			7	1	11	543	0	11
Coal	1	10						
Fireclay and bast	3	11	2	1	1	545	2	0
Coal	1	4						
Rock and clift			5	1	0	551	0	0
Coal	1	4	0	1	4	551	1	4
Fireclay and clift			4	2	9	556	1	1
Coal (probably the No. 3 Ynysybwl of Albion.)	3	3						
Hard clod (probably the No. 3 Ynysybwl of Albion.)	2	6	2	1	11	559	0	0
Coal (probably the No. 3 Ynysybwl of Albion.)	2	2						
Fireclay and clift with mine			5	2	2	564	2	2
Coal and clod, alternating			0	1	11	565	1	1
Fireclay and clift			7	1	10	572	2	11
Coal	2	8						
Clod	1	2						
Coal	0	3	2	2	1	575	2	0
Clod	2	11						
Coal	1	1						
Fireclay and clift with mine			7	2	3	583	1	3
Coal	1	7						
Rashings, ground disturbed	5	8	2	2	3	586	0	6
Coal	1	0						
Disturbed ground, probably a fault			3	2	7	590	0	1
Clift with mine			58	1	8	648	1	9

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The section compares most nearly with the Albion Colliery (No. 18, Sheet 80 Vertical Sections), which lies nearly two miles to the north-west. No. 2 Rhondda, however, is quite unrepresented in the Aber section, and in place of it there is thick sandstone with some conglomeratic bands. No. 3 Ynysybwl of Albion appears to be the Nine-Feet Seam of Harris' and the Dowlais-Cardiff Shafts, which is the Black Vein of the South Crop and the Ras-las of the North Crop.

But little is known at present of the faults in the Aber Valley, except those proved in the Mynyddislwyn Vein. The largest of these is a downthrow north-east of 85 yards, and it passes under Old Furnace and ranges so as to pass up the valley a little to the east of Aber Station. The Tir Gibbon Fault is a downthrow south-west of about 80 yards, parallel to, but 600 yards to the north-east of the Old Furnace Fault.

The seam identified at Aber as the No. 3 Ynysybwl lies 1,037 feet below Ordnance Datum, as compared with about 1,490 feet at Albion, two miles to the N.W., although the measures at Aber dip south. This is due principally to the Pontypridd anticline, in consequence of which the dip (as observed at the surface) changes about 400 yards north of the Aber shafts to north-west, and so continues all across Mynydd Eglwysilan and the Nant-cae-dudwg. The position of the Lancaster Pit with respect to the anticline resembles rather that of Llanbradach, where the Black Vein (corresponding to the No. 3 Ynysybwl) was reached at 1,160 feet below Ordnance Datum. The anticline it will be noticed here runs south-west, to Pentrebach, where its position was ascertained by observing the gradual rise of some rock-outcrops along the hillside to the crest of the anticline. At Pentre-bach it is crossed by the Darenddu Fault, which with the Ty-mawr Fault about 1,000 yards further west, throws down a deep trough under the Taff. West of the trough, in Sheet 148, the anticline increases greatly in intensity.

The Taff Valley.

In the Taff Vale the lower coals have not yet been touched between Craig-yr-allt and Pontypridd. Not only do they there lie at a great depth beneath the Caerphilly syncline, but there is reason to think that the faulted trough above alluded to follows the valley. The Darenddu Fault has been proved at the colliery of that name in Sheet 248, and thence runs along the eastern edge of Coed-pen-main Common, 150 yards east of the Rocking Stone; thence it passes along the lower edge of Glyn Taff Wood, and either through or close to a quarry near the southern end of the wood. South of this point its course becomes uncertain, but it doubtless continues to follow the eastern slopes of the valley past Upper Boat. The fault is a downthrow west of unknown amount. The Ty-mawr Fault has been proved to be a great downthrow east at the Great Western Colliery, and can be traced thence with ease across the hill west of Treforest, to the southern end of the Barry Railway Tunnel, where it enters the map under descrip-

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tion. It thence keeps along the Taff Vale Railway as far at least as the road from Upper Boat, where what may be either the main fault, or only a branch of it, has been proved in the Llantwit seams to have a downthrow east of 55 yards, and to run from Maes-mawr Colliery under Maes-bach; by surface-evidence it may be traced thence on the east side of Lan into the Taff Valley west of Glan-y-llyn. This fault ranges for the warm spring known as Taff's Well (p. 90) and for the limestone-gorge, but it will be remembered that it was previously inferred from the relative position of the outcrops both of Coal Measures and limestone that a large downthrow *west* must run under this part of the Taff. It seems possible, therefore, that the Darenddu Fault may continue thus far; but the only westerly downthrow yet proved is a fault under the east bank of the river at Willow Ford, which is said to have thrown No. 3 Llantwit 30 yards or more down on the west. An account of the remainder of the faults and of the Llantwit coals is reserved for the description of the upper measures (p. 69).

On the north side of the anticline the lower coals are being energetically worked. The Pontypridd Collieries fall within Sheet 248, but Albion, the Dowlais-Cardiff shafts at Navigation, and Harris' Navigation* lie within the map under description. At Albion the Nine-Feet Seam occurs at about 1,490 feet below Ordnance Datum, at Navigation 1,900 feet, and at Harris's 1,730 feet below that level. The syncline thus indicated is the one which has already been referred to as traversing the Blackwood outlier of Mynyddislwyn Coal, and which will be described later on. The Dowlais-Cardiff shafts, however, are not in the deepest part of the trough, but about 700 yards south of it, for the Pennant continues to dip northwards for that distance. In Cwm Mafon and in the hill between the Taff and Cynon Valleys it dips south-east, and the synclinal trough accordingly runs south-west, but soon becomes shallow.

The only faults proved so far are a small downthrow east in the Albion workings, and the Werfa and Llanfabon Faults at Harris's Navigation. The Werfa Fault has been ascertained to be a downthrow east of 27 yards in the Four-Foot Vein near Quaker's Yard. Its position on surface appears to be indicated by a break in the ground 300 yards north of the station, and by the gap in the rocky promontory of Goitre-coed-fach which is utilised for the railway and canal. Of its course further south we have little evidence, and as there is no sign of it in the Craig-berth-lwyd we can only assume that it may run up Cwm Mafon. It diminishes rapidly southwards, and seems to be on the point of dying out at Goitre-coed. A small fault was noticed by Mr. Gibson in an old quarry at Goitre-coed-fach and in the Taff below, while two others cross the railway below Goitre-coed Cottages, probably to the east of the Werfa Fault.

The Llanfabon Fault enters the map under description on Cefn Merthyr, where it has been proved in the Four-Foot

* Nos. 18, 17, and 16 in Sheet 80, Vertical Sections.

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workings from Merthyr Vale (Sheet 248). It has next been found under Cwm Cothi in the Six-Foot workings from Harris' Navigation, where its position on surface also is traceable by the fact that it throws in a small outlier of the Mynyddislwyn Coal. It was traversed also by the pits, in the more northern of which it appeared as a clean cut with parallel walls, entering the shaft (which is 17 feet in diameter) at 69 yards, and leaving it at 87 yards depth, which indicates a hade of nearly 1 in 3. In the south pit, however, one of the fault-walls was so irregular that after leaving the shaft it re-entered it lower down. The throw has been proved here to be 54 yards down to the east, for a cross-measure drift through it from the Six-Foot workings cut the Four-Foot Seam at a depth of 80 feet, which, added to the distance between the Four-Foot and Six-Foot Seams, gives 54 yards.

South of the colliery it has been noticed by Mr. Gibson at an elbow in the Bargoed-Taff near Pont Squire, and it can be traced close by the Park Quarries and by Singrug, where it throws in the Mynyddislwyn measures of Llancaiach. Thence it has been continuously proved through those measures, and can be followed without difficulty to the Rhymney Valley (p. 53). Its throw is reported to be 140 yards at Llancaiach.

Some small seams in the Pennant may be noticed in this part of the Taff Valley. One of them, locally known as the Stinking Vein and very sulphury, has been tried at Pont Shon Norton. Another, about 130 yards above, has been worked at Hendre Prosser, and runs on to Bedwenarth Wood, in the upper part of which there is an old trial-level. At Cilfynydd a level opened in what seemed to be this vein proved:—

Seam in the Pennant near Cilfynydd.

	ft.	in.
Shale	1	6
Coal	0	5½
Rashes	0	½
Coal	0	3½
Soft clod	0	1
Coal	0	½
Fireclay	1	2
Coal	0	7
Parting		—
Coal	0	10
Fireclay		—

The seam lies about 630 yards above the No. 3 Ynysybwl (Nine-Foot Vein) of Albion, and may therefore be the Cefn-glas Seam, which lies 636 yards above the Nine-Foot Seam at Harris's Navigation. This was also known as the Stinking Vein; another Stinking Vein, which crops out at Pont Douglas, near the Dowlais-Cardiff shafts, lies about 730 yards above the Nine-Foot Coal.

But the true positions of these veins can be better discussed by reference to their height above the Rhondda No. 2 Seam. Although that coal was not satisfactorily determined in the Dowlais-Cardiff Shaft, it will be seen by reference to Sheet 80,

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Vertical Sections, that it is probably represented by three thin coals with clod at a depth of 231 yards 2 feet; for these occur at the same height above the Nine-Foot Seam as the Rhondda No. 2 of Harris'; while above them, as in the case of Rhondda No. 2 at Albion and in the above mentioned shafts, we find a great mass of rock, and below them measures with white rock and conglomerate.

Now the Pont Shon Norton Seam appears to have been traversed by the Albion Shaft at a depth of 67 yards 2 feet (61 yards above Rhondda No. 2) at the Dowlais-Cardiff what was probably the same vein lay at a depth of 170 yards 1 foot (61 yards above the supposed Rhondda No. 2), while it may be represented at Harris' by a thin seam at 160 yards depth (80 yards above Rhondda No. 2).

The Hendre Prosser Vein lies about 130 yards above the Pont Shon Norton Vein, and would therefore be about 191 yards above Rhondda No. 2 at Albion. At the Dowlas-Cardiff Pit it may be represented by a seam at 71 yards depth (161 yards above Rhondda No. 2) and at Harris' by the Cefn-glas Seam at 106 yards depth (134 yards above Rhondda No. 2). It will be noticed that the Rhondda No. 2 Seam must be in or close below the river-bed between Pont Shon Norton and the Daren-ddu Fault.

In its course north of Treharris the Taff, as noted by Mr. Gibson, traverses a descending section of Pennant, devoid of coal-crops except for a rider from 1½ to 2 ft. thick, which comes out under massive sandstone in a railway-cutting one mile south of Cwm-felin, and which has been worked half a mile south-east of that place; below it there lies a second coal, 1 ft. 2in. thick, but not well exposed. The rider approximately corresponds in position with the Cefn-glas Seam of the district further west, and possibly represents it.

The Brithdir (Tillery) Seam lies about 80 yards below the rider, and rises from beneath the river at Cwm-felin at 625 feet above Ordnance Datum. It has been worked by a series of levels on the east side and more recently by the Bedlwynog and Nant-wen Shafts (Sheet 232). On the west side of the valley these crops are not to be distinguished, probably owing to the Gelligaer Fault which runs at the foot of Coed-y-cae. This fault has been proved to be a downthrow west of 100 yards in the Mynyddislwyn workings near Llancaiach and seems to have been touched in the Brithdir workings 100 yards north-east of Nant-fedw. Thence it runs through Troed-y-rhiw (Sheet 231) with a downthrow west of 47 yards, and becomes the Merthyr Church Fault.

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CHAPTER VII.

CARBONIFEROUS.—*(Continued.)*

COAL MEASURES.—*(Continued.)*

The Mynyddislwyn and Llantwit Veins.

The Mynyddislwyn Vein, the highest seam of the eastern end of the Coal Field, occurs in the synclines of Blackwood and Caerphilly and in the outliers of Cefn Crib. It yields the best house-coal in South Wales, but has been nearly worked out. In the Blackwood Basin the Mynyddislwyn coal is double, the two parts sometimes getting several yards apart, and about 108 yards above it there occurs a rider, which has been but little worked. In the Caerphilly Basin the Mynyddislwyn Seam occurs as a single coal under the name of the Llantwit-Bedwas. A rider has been proved at Rhos Llantwit 121 yards above it, and there are some thin seams at no great depth below it, which become workable and constitute the Llantwit group further west. The Caerphilly syncline runs westward across the Taff, but is not deep enough to bring in the Mynyddislwyn Seam along that valley.

(1) *The Blackwood and Pengam Basin.*

This basin of Mynyddislwyn measures owes its existence to a faulted syncline, which runs in a direction E. 30° N. to W. 30° S. Including the outlying patch of Cefn Crib, the tract extends to a length of about 9½ miles in the direction named. The syncline commences close to the eastern margin of the Coal Field, and is recognisable, though quite shallow, in the Mynyddislwyn and Tillery workings under the southern side of the Cefn Crib; here it is accompanied by the Trevethin Fault, which has a considerable downthrow south, but dies away at Blaen-y-cwm. Somewhat to the south of the outlier runs the Glyn Fault, described on p. 50, which is a downthrow north, and is principally instrumental in bringing in these upper measures. The Mynyddislwyn Vein descends to a level of 1,000 feet above the sea on Cefn Crib.

West of the Ebbw the syncline deepens and the vein descends to 500 feet above the sea at Cwm-gae-gwyn Colliery (Cwm-dows Colliery on the six-inch map). Thence the trough runs between the New Tir Philkins Colliery and the Woodfield Pit, in which the vein lies at 217 and 237 feet respectively above sea-level. It is crossed, however, not only by the Cwm-dows Fault, a downthrow north of 60 yards, but by a series of N.N.W. dislocations, which make it difficult to fix the exact position of the syncline. At the old Llys-pen-twyn Pit, 700 yards N.E. of Tir Philkins, the vein lay at 297 feet above Ordnance Datum. The following section of that pit was collected by Mr. W. Adams for the Royal Coal Commission, 1871, and will serve to illustrate the measures of this part of the Mynyddislwyn Field.

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Llys-pen-twyn Pit, one mile N.N.E. of Pont-llan-fraith.

	Thickness.	Depth from Surface.
	Yds. ft. in.	Yds. ft. in.
Gravel	11 0 0	11 0 0
Measures	2 0 0	
Coal	0 0 6	13 0 6
Measures	1 1 0	
Coal	0 0 6	14 2 0
Measures	2 1 0	
Coal (Rider)	0 2 6	17 2 6
Measures	5 1 6	
Coal (Rider)	0 1 7	23 2 7
Rock	1 1 10	
Fireclay	1 1 0	
Measures	4 0 0	
Fireclay	3 1 0	
Measures	16 0 6	
Rough Rock	31 2 0	
Coal	0 0 4	82 0 3
Measures	3 2 0	
Coal	0 0 8	85 2 11
Measures	2 2 0	
Coal Rock	21 0 0	
Mynyddislwyn Vein	1 0 6	110 2 5

In the Sirhowy Valley the deepest part of the syncline lies close to the southern boundary-fault (Gelligroes Fault), where the vein is only 160 ft. above Ordnance Datum, but thence westward it shallows rapidly, for at the Libanus the vein is 420 ft. above the sea, at the east end of the tunnel 400 ft., at the Bryn Pit 420 ft., and near Maes-y-cwmmer 500 ft. above that level. This syncline, therefore, dies away near Maes-y-cwmmer.

Another syncline, however, appears at Pengam, 1½ miles further north, and runs through Gelligaer and Nelson. Rhos Colliery, which lies probably in the deepest part of the trough, proved the vein at 200 ft. above Ordnance Datum, while the Flower Pit at Fleur-de-lis, a little south of the axis, reached the vein at 350 ft. above that datum, and the Gilfach Pit, a little north of the axis, reached the vein at 370 ft. above the datum. Thence the synclinal axis runs south-westwards under the peat-moss of Waun-rhydd, through the Gelligaer Colliery to Nelson, whence its course in the Pennant has already been traced (p. 57). In the trough thrown down between the Gelligaer and Llanfabon Faults (p. 53), the vein gets so low as 176 ft. above Ordnance Datum.

The numerous faults of the Blackwood and Pengam Basin fall into two well-marked systems. The one runs parallel to the synclinal folds in a N.E.—S.W. direction, and includes the Glyn, Trevethin, Cwm-dows, and Gelli-groes Faults; the other follows the N.N.W. course, so prevalent in the South Wales Coal Field, and includes the Pen-y-Fan, Pengam, Pendaren, Rhos, Gelligaer, and Llanfabon Faults.

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The Glyn Fault has already been noticed (p. 50). It forms the southern boundary of the Mynyddislwyn measures near the Parish Church, and was known to the old miners as the Farewell Fault.

The Trevethin Fault, which alone of those mentioned is a downthrow south, dies away soon after entering the map under description.

The Gelli-groes Fault is small near Cwm-dows, but increases to 15 yards at Tan-y-moch, and becomes large in and west of the Sirhowy Valley. In the Rhymney Valley, however, it disappears.

The Cwm-dows Fault has a downthrow north of 60 yards where it crosses the Great Western Railway, but is not recognised at Crumlin. At New Tir Philkins Colliery it appears to have branched, one portion of it with a throw of 40 yards ranging nearly for the Gelli-groes Pits. The unexpected depth of the Mynyddislwyn Vein here was due, therefore, to a combination of these north-easterly faults with the Pengam Fault, presently to be described. Of the many other north-easterly faults shown on the map mention need be made of the one only which falls nearly into a line with the Cwm-dows Fault northwards, but is a downthrow in the opposite direction. It repeats the outcrop of the Mynyddislwyn Vein near Croes-pen-maen, and runs thence through Ton-tir-bel to Aberbyg, where it was proved to be a downthrow east of 25 yards in the Tillery Vein. According to an old miner a level was driven from Trinant up to this fault, which was then "roughed up" for 102 yards, and the workings continued down a dip-slope to Waterloo.

In the N.N.W. system of faults mention may be made of a downthrow west of 20 yards, proved in the Mynyddislwyn and Tillery Veins at Llanhilleth, which, however, is not recognized south of Swffryd.

The Pen-y-Fan Fault comes next, and with another to the west of it throws down a trough of measures 50 yards in depth at Pen-y-Fan (Sheet 232). These die away near the northern margin of the sheet under description.

The Pengam Fault commences at the Wingfield Pits, and was proved to be 90 yards downthrow west at Pengam by the fact that the Mynyddislwyn Vein lay at a depth of 110 yards in the Gilfach Pit and 90 yards in the Newplace Pit, though it is close to the surface on the other side of the fault. At Pen-llwyn-fawr its throw diminishes to 66 yards, and then to 33 yards, while in the Sirhowy Valley it has not been identified with certainty, though it probably crosses north of the Gelli-groes Pits, and helps to account for the depth of the Mynyddislwyn Seam at that spot. On the east of the Sirhowy the fault which throws in a small outlier of that coal at Caer-llwyn (see also p. 52) falls nearly into the right line, and may be continuous with the Pengam Fault.

Near the spot where the Pengam Fault dies away northwards, a parallel fault, also with a downthrow west, springs into existence 100 yards further east. This attains a throw of 59 yards near Heol-ddu-uchaf, and becomes the Dowlais Fault of the North Crop.

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The Pendaren and Rhos Faults are both downthrows to the east, and thus form a trough with the Pengam and Dowlais Faults. The Pendaren Fault starts at the Wingfield Pits and increases southwards to 90 yards at the Rhos Colliery, but falls to 70 yards at Glan Rhymney. It is not traceable in the Pennant, but may be continuous with one of the faults proved near Maes-y-Cwmmer. The Rhos Fault springs into existence near where the Pendaren Fault dies away and thus takes its place. Three-quarters of a mile south of Wingfield Pit it has a throw of 95 yards.

The Gelligaer and Llanfabon Faults throw down a trough no less marked than the one just described. Their courses have already been noted (pp. 53, 59).

The Mynyddislwyn Vein of the Cefn Crib outlier is double, and in the southern part is said to have consisted of 4½ feet of top coal and 2½ feet of bottom coal, with 15 feet of shale between, but at Blaen-y-cyffin (Sheet 232) there was only 2½ feet between the two coals.

A new level in Cwm-y-glo, near Llanhilleth, exposed the following section:—

	Ft.	in.
Massive sandstone	—	
Sandy shale	4	0
Top Coal	3	10
Shale, &c. } Mynyddislwyn Vein	6	0
Bottom Coal	2	1
Clay with streaks of coal	2	6
Clay seen to	2	0

Near the spot there is a rider 30 yards above the vein, and another higher up on Mynydd Pen-y-fan, from which, however, no coal has been raised.

At Kendon the top and bottom coals are 9 feet apart and at Cwm-dows from 21 to 24 feet apart, the distance increasing southwards as on Cefn Crib. The same southerly thickening of the shale takes place in the Sirhowy Valley, where the bed varies from nothing on Pen-y-fan (Sheet 232), 1 to 1½ feet at Gwrhay, 4 to 6 feet at Waterloo and Rock, to 17 feet at Pont-llan-fraith. The top coal is of the best quality, but is almost exhausted, and the bottom coal is now being worked together with the pillars of top coal left by former companies. At Cwrt Coch Colliery, south-west of Bedwellty, the parting was 1 foot 8 inches thick (the top coal being 2 feet 8 inches), and on the north side of Gelligaer the top coal is 3 feet, the shale 1 to 1½ feet, and the bottom coal 2 to 3 feet thick.

Of the two riders above the Mynyddislwyn Vein one is intersected by the tunnel between Tredegar Junction and Maes-y-cwmmer and is said to be from 15 inches to 3 feet thick; this lies about 30 yards above the vein. A more important seam, known as the Big Rider, occurs 108 yards above the vein at Gilfach, or 82 yards above the Small Rider at that spot. The Big Rider is being worked at the old Rhos Colliery, but is inferior to the Mynyddislwyn Vein; it has shale above and below, and including shale-partings measures 2 feet 9 inches to 2 feet 10 inches in thickness.

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A Black Band Ironstone* occurs about 27 yards above the Mynyddislwyn Vein. At Wingfield it consists of good ironstone 2 feet thick, a shale-parting 2½ feet thick, and a lower ironstone 2 feet 3 inches thick; near Gilfach it includes five bands of ironstone, totalling 4 feet 11 inches in thickness, with partings amounting to 3 feet 8½ inches. It was described in 1870 by Prof. T. Rupert Jones,† from whose paper the following notes are taken:—

The Ironstone occurred in some bituminous shales full of *Anthracomya Phillipsi*, Williamson, with some *Estheria tenella* and many small Cytheroid forms. *Leaia* was abundant on some slabs. There occurred also black shining circular spots with irregularly concentric wrinkles, which have been explained by Mr. Carruthers as being vents in the mud of gases from decomposing organic matter. This shale was associated with the Black Band Ironstone, which was struck in a level one and a-half mile south-west of Bedwellty Church, and one and a-quarter mile north-east of Gelligaer Church, on the west of the Rhymney. After driving westward in the coal, the miners struck a fault with a downthrow west of 25 or 30 yards, and entered the Black Band. The band was thought to be the equivalent of the Rider Coal, 1 foot thick, 27 yards 0 feet 6 inches above the Mynyddislwyn. At Llancaiach Colliery the band occurs again with the same shells. The same *Anthracomya* occurs at Aberbyg over the Troed-rhiw-clawdd (Tillery) Coal.

Fossils of the Black Band, Gilfach.

Estheria Adamsi, *Jones.*
Carbonia Evelinæ, *Jones.*
Carbonia Agnes, *Jones.*
Carbonia (?) sp.
Leaia Leidyi, *Jones.*
Daphnoid entomostraca.

At Llancaiach the Black Band consists of a top bed of ironstone, 8 inches thick, holing 3 inches, and a middle and bottom bed, together 2 feet 6 inches thick.

The rock immediately overlying the Mynyddislwyn Vein is a massive felspathic grit, scarcely distinguishable from Pennant; but these higher measures generally are softer, and do not form the mountain-land and crag characteristic of that formation. Below the vein there runs for some miles an evenly-bedded flaggy sandstone, which is valuable for paving, &c. It is extensively worked for this purpose on Cefn Crib and near Llancaiach. The bedding-planes, more often than not, are due to current-bedding, and are oblique to the true stratification of the rock. This, however, is immaterial so long as the stone splits readily into good slabs. Suitable stone occurs at more than one horizon.

* Black Band is a name applied to an argillaceous ironstone which contains sufficient carbonaceous matter to calcine itself when fired, without the addition of fuel.

† *Geol. Mag.* Vol. vii., page 214.

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(2) *The Caerphilly and Llantwit Syncline.*

This syncline commences near Nant-y-Ceisiad, and, deepening rapidly, brings in the Mynyddislwyn Vein (here often known as the Llantwit or Llantwit-Bedwas Vein) two-thirds of a mile further west. The coal seems to be thrown in partly by a fault which is to be seen in the Newport and Pontypridd Railway, and partly by the westerly dip. The crop of the seam is fixed by some old workings in the Red Brook below the Brecon and Merthyr Railway, and may be traced thence by Tyn-y-wern to an old level near the Llanfabon Fault.

The seam at its outcrop runs at 350 to 400 feet above Ordnance Datum, but at the Cwm-y-glo Colliery (Vert. Sections, Sheet 80, Section 3) lies 60 yards below the surface, or about 20 feet above that datum, while it descends in the axis of the syncline, under the alluvial flat of Pant-glas, to nearly 100 feet below the datum. Its rise on the south side of the syncline is no less rapid, for it comes to the surface at Gwaun-y-Bara and in Maerdy Wood, while it was proved at 19 yards depth at Gwern-y-domen, this crop running at 250 to 300 feet above Ordnance Datum. The average dip, both from the north and south, into the east end of the syncline appears to be about 1 in 6.

At Bedwas the syncline is crossed by the Llanfabon Fault, which has been proved to have a downthrow east exceeding 15 yards, and is believed to amount to 45 yards; the throw diminishes, however, to 20 yards south of the syncline, and is not distinguishable in the Pennant. The northward continuation of the Llanfabon Fault is given on p. 53.

At the Bryn-gwyn Colliery a slope was driven for upwards of 900 yards down the dip, the gradient ranging from 9 inches to the yard near the mouth to 4½ inches to the yard near the axis of the syncline. The Rhos Llantwit Colliery (Vert. Sections, Sheet 80, Section 4) lies nearly in the line of the slope, but on the other side of the axis, and proved the vein to lie 240 feet below Ordnance Datum. It is evident, therefore, that the trough deepens from Cwm-y-glo westwards to Rhos Llantwit, the "pitch," or rate of deepening, being about 1 in 33. This would seem to be about the deepest part of the basin, for at Caerphilly the coal has been worked at 60 feet below Ordnance Datum (120 yards depth), and was, moreover, proved to rise westwards as well as northwards and southwards. This observation was made on the north side of Caerphilly; but there seems to be a small subsidiary hollow about 200 yards south-west of the Castle, for the coal there lay horizontally, though it is 600 yards south of the synclinal axis.

The Mynyddislwyn or Llantwit Vein of the Rhos Llantwit Colliery is four feet thick, the upper eight inches, however, being used only for engine-coal, while the remainder is a valuable gas-coal. It is said to contain more gas than the same seam at Mynyddislwyn, and to give a white instead of a red ash. It is overlain by a massive Pennant-like sandstone, and about five yards below it there is said to be a rider six inches thick. All of the collieries in the Caerphilly Basin had ceased work before

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the resurvey of the area was completed, principally it is stated from want of combination in dealing with the water.

The faults of this basin fall generally into the N.N.W. system. With one exception only, none of them can be detected in the Pennant south of the Caerphilly Basin. At Bryn-gwyn so large a number of faults intersects in all directions that it was impossible to show them all upon the six-inch map; groups of faults and belts of faulty ground are, therefore, indicated by single lines and the general effect of the dislocations represented.

A dislocation with a downthrow west at Pwll-y-pant passes under Virginia House and runs to the Van, whence it may be traced on through the Millstone Grit and Carboniferous Limestone. This appeared as a belt of faulted ground with an aggregate downthrow west of 100 yards in the synclinal trough.

The Eneu'r-glyn Fault is a downthrow north-east of 35 yards, but splits up and dies away southwards near Virginia House.

The Tir Gibbon Fault is a downthrow south-west, and is reported to be 80 yards where it crosses the Aber Valley Railway.

The Old Furnace Fault is proved to be a downthrow to the north-east of about 85 yards by the fact that it throws the Llantwit Vein down from the outcrop on the west to a depth of 74 yards in the Pen-yr-heol Shaft on the east (Vert. Sects. Sheet 80, Section 5).

The western and southern crop of the Llantwit-Bedwas Vein of Caerphilly is hypothetical. The Hendre-denny workings proved it to extend at least as far westward as is shown upon the map, while a shaft near Gwaun-gledyr-uchaf is said to be 63 yards deep and to have proved no coal, from which it may be inferred that it is west of the outcrop of and in measures below the Llantwit Vein. A borehole 250 yards further south is said to be 150 yards deep; it yields water overflowing at the surface.

Of other seams occurring in the Caerphilly Basin, mention may be made of the rider proved at Rhos Llantwit 120 yards above the Llantwit Vein. It consisted of an upper seam 1 foot 10 inches thick, and a lower seam 1 foot 6 inches thick, but occupies a small area in the deepest part of the basin only, and has not been worked. There are also some small seams below the Llantwit Vein which become more important westwards. One of these is said to have been proved to have a thickness of 12 to 18 inches, and to lie 13 yards below the Llantwit Vein near Rhos Llantwit. A small seam also has been worked at Pen-twyn-gwyn under the name of Edward's Vein; another crops out under Chapel Farm and in old levels to the east of it, while a coal-smut with shale rises to the surface 150 yards further south. One of these veins crops out also south and east of Hendre-denny Hall, but none of them are of any commercial value.

Reference has already been made to some seams in the upper part of the Pennant of the Sirhowy Valley (page 52). On Twyn-yr-Oerfel, a rider crops out; 100 yards lower down the Ochr Chwith seam has been recently opened out, and about 75 yards

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lower down again there are old mouths upon a "Dirty Vein." The section of the Ochr Chwith Seam, as supplied by Prof. Galloway, was as follows:—

Sirhowy Valley.

	Ft.	in.
Clod with bands of rock at the base	—	
Coal	3	4
Parting	0	0½
Coal	0	4
Rashings	1	6
White clod	—	

The outcrops of these seams occur on or near the brow in which the dip-slope above the Caerphilly Basin terminates. They lie, therefore, high up in the Pennant, and not improbably correspond to the Coed Cae-dyrys and Stinking Veins, about to be described.

Though the Caerphilly Basin ends as described, the syncline continues westwards in pronounced form across the Taff Valley and west of it. On the east side of that valley a seam of local development has been worked under the name of the Coed Cae-dyrys Vein. It varies from 1 foot 6 inches to 1 foot 10 inches in thickness, is very sulphury. and has a soft clod above it. The dips indicated on the map, and the form of the outcrop also, show that the seam lies in a trough the axis of which lies in the southern part of Coed Cae-dyrys, and which is in a direct line with the Caerphilly syncline to the east and the Llantwit syncline to the west. The easterly dip at the centre of the trough further indicates that the same rise of the strata which determines the west end of the Caerphilly Basin still continues. The inclination as observed in the workings amounted to 1 in 6, and if this continued to the Caerphilly Basin it would indicate that the Coed Cae-dyrys Vein must lie about 265 yards below the Llantwit Vein, but the actual distance is probably much less. The following section of the vein was supplied by Mr. David Thomas of Llantwit:—

The Coed Cae-dyrys Vein at the Pen-y-groes Level.

	Ft.	in.
Top coal	1	4
Clod — 1 ft. 3 in. to	2	0
Bottom coal	1	4
Bastard fireclay, with nodules of ironstone	—	

About 80 yards below the Coed Cae-dyrys a "Stinking Vein" has been proved by boring and by a level at Tair, while about 30 yards lower down again a thin coal crops out in the Newport and Pontypridd Railway at Cross Roads.

It is commonly reported that the Llantwit Four-Foot lies 25 yards below the Coed Cae-dyrys Vein, and a level was being commenced at Ffynnon-wen in search of it in 1893. About one and three-quarter miles up the valley, at Pant-drain, there is an old level in which the Llantwit Four-Foot is said to have been worked with a thickness of 2½ to 3 feet, while at the southern

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end of the same ravine there is a level in what is called the "Stinking or Dirty Vein." The crops of the Coed Cae-dyrys and Stinking Vein seem, however, to run much higher up round Mynydd Mayo, and it appears that the names "Stinking" and "Dirty" are to be taken rather as indicative of the character of the coals than of their stratigraphical position.

Reference has previously been made to the N.N.W. faults under the Taff Valley near Nant Garw (pp. 56, 57). But little is known of them at present except that a westerly downthrow of 30 yards or more was proved to pass 150 yards east of the Rhyd-yr-helig shaft, in the easternmost workings from that colliery. The next fault westwards is a downthrow east of 55 yards proved in the Llantwit Four-Foot (see also p. 57), and 500 to 550 yards further there is a downthrow east of 47 yards which ranges to Pant-Evan-ddu. The Ton-têg Fault, 200 yards further west again, is a downthrow east of 26 yards and joins the last-mentioned at Pant-Evan-ddu. These have both been proved in Llantwit No. 3. Lastly the Stank Fault is a downthrow west of 60 yards.

The syncline, a deep narrow trough, though doubtless shifted keeps its course through all the N.N.W. faults from Caerphilly through Coed Cae-dyrys, Willow Ford, and along the Dowlais Brook. Rhyd-yr-helig Colliery lies in the centre of it and both to the north and south of it the Pennant rock can be seen rising in the banks of the river at 25° to 30°. The Taff Llantwit Colliery occupies a similar position south of Church Village Station, for Llantwit No. 3 descends from the surface 60 yards north of the shaft, passes under it at a depth of 29 yards, and comes to the surface again 170 yards south of it. Just beyond the margin of the map the syncline deepens and brings in the whole Llantwit group, of which the general section follows:—

General Section of the Llantwit Measures.

Llantwit.	yds.	Caerphilly (probable equivalents).
Measures	77	
No. 1 Llantwit Seam		Llantwit-Bedwas or Mynyddislwyn Vein.
Measures	87	Not proved.
No. 2 Llantwit (or Cistern) Seam		Coed Cae-dyrys and (?) Ochr Chwith Vein.
Measures	8	Reputed to be 25 yards.
Coal		
Measures	22	
No. 3 Llantwit, Llantwit Four-Foot or Maes-mawr Seam		(?) Not proved.
Measures	55	
Pen-y-groes or Pen-coed-cae Vein		(?) Stinking or Dirty Vein.

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The Rhyd-yr-helig Pit (Vert. Sections, Sheet 80, Section 6) reached No. 1 Llantwit at 57 yards, No. 2 Llantwit at 138 yards, and the Llantwit Four-Foot at 172 yards depth. Insole's Shaft at Maesmawr was sunk 60 yards to the Llantwit Four-Foot. This vein lay at 316 feet below Ordnance Datum at Rhyd-yr-helig, but only 20 feet below at Insole's, which gives a rise of about 1 in 8. The dip is much steeper than this in the trough of the syncline, but lessens at Maesmawr, and, moreover, turns to the south-west.

At the Taff Llantwit Colliery, No. 3 Llantwit lies 160 feet above Ordnance Datum, or 476 higher than at Rhyd-yr-helig, but the difference is partly accounted by the faults enumerated above, three of which have a united downthrow east of 384 feet. Further west the vein is thrown down again by the Stank Fault, the Ystrad Barwig Fault* (down west 99 yards), and another,* down west 60 yards, with the result that it lies 340 feet below Ordnance Datum at Ystrad Barwig.* A mile or two further on the syncline fills up.

* In Sheet 248.

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CHAPTER VIII.

SECONDARY ROCKS.

The New Red or Keuper Marl, Rhætic Beds, and Lias are the only Secondary strata represented in South Wales. They come to the surface in a small area between the hills of Old Red Sandstone and the alluvial tract of Goldcliff, and at Maes-glâs. There can be little doubt that they underlie much of the alluvium, for after disappearing beneath that deposit between Newport and Cardiff they re-emerge at the latter place, as before, at the feet of the hills formed by the older rocks. It is, moreover, a noticeable fact that the existing landscape of the South Wales coast-region bears a relation to the Triassic landscape, for some of the prominences formed by the older rocks stood up as islands and headlands in the Triassic waters, while, in what is low ground now, the Secondary rocks attain their greatest thickness. Presumably, therefore, parts of the Bristol Channel coincide more or less closely with a bay in the early Secondary coast-line.

New Red or Keuper Marls.

This formation crops out on the south side of Christchurch Hill, and in a small inlier in the alluvium of Maes-glâs. Another small inlier occurs near Goldcliff, just outside the eastern margin of the map under description. In the absence of any basement-breccia or conglomerate the marl rests directly upon marls of Old Red Sandstone age, and is not easily distinguished from them. At Maes-glâs the Lias and Rhætic Beds are faulted against the Trias, but whether the latter is faulted against the Old Red Sandstone or not must remain uncertain. More probably there is a natural boundary between them to and beyond Cardiff.

The greater part of the Keuper deposit consists of soft homogeneous red marl, slightly brighter in tint than that belonging to the Old Red formation. It is mottled with green spots, and in its upper part becomes green, slightly mottled with red, or interstratified with an occasional pale-red band. In this part also there appear some fine-grained stone-bands, and thin tufaceous, calcareous bands, presenting at a distance no little resemblance to Rhætic strata. These "tea-green marls," as they have come to be called, differ markedly from the New Red Marl below, and indicate the progress of that change by which the sea eventually gained access to the area in Rhætic times. At the same time they are distinguished from the Rhætic formation by the fact that they have hitherto proved to be totally unfossiliferous in South Wales, except for the occurrence of a bone-bed at Goldcliff (p. 75).

A general account of the Rhætic strata is reserved for the Memoirs on Sheets 263 (Cardiff) and 262 (Bridgend), in which they are more fully displayed, but a few words may be devoted here to a change in classification introduced on the map now for the

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first time. The "tea-green marls," which are constant, and readily identified on both sides of the Bristol Channel, were included in the Rhætic formation in the former edition of the map, and as far as thickness went constituted a considerable part of that formation. They are now excluded for the following reasons. In the first place no line can be drawn between them and the Red Marls which does not include typical red beds in the green series, or green beds in the red series. The gradation from one to the other is perfect, even the green marls themselves being of the usual Triassic type except in colour. On the other hand there is a definite plane of separation between the "tea-green" series and the black shales in which the Rhætic fauna first appears. Marls of Triassic type, whether red or green, and the cavernous inorganic calcareous bands, occur below that plane, while above it we find shales and thin limestones crowded with organic remains. The plane itself is not infrequently accompanied by an inch or two of conglomerate, consisting of quartz-pebbles, rolled teeth and bone-fragments, which, without indicating an actual unconformity, points to an abrupt change of physical conditions. Taken in connection with the usually sudden appearance above it of the Rhætic fauna, it suggests the first complete invasion of the area by the Rhætic sea.

Though this invasion seems to have been sudden, the subsidence of the Triassic land which caused it was probably gradual and continuous. For in the western parts of the Rhætic area of Glamorganshire we find proof of the local and temporary recurrence of Keuper Marl conditions in Rhætic times, red and green marls indistinguishable from the Keuper Marl being there intercalated in fossiliferous Rhætic strata. The series, as a whole, presents to us such a sequence of events as is indicated by the Wealden and Neocomian beds of the South of England. The red marls of the Keuper, characterised by the precipitation of peroxide of iron, salt, and various sulphates, are closely matched by the red marls of the Wealden, and both were probably deposited in land-locked waters. The tea-green series, in which these ingredients were not precipitated, was distributed by water which was not super-saturated, and which presumably had a more open outlet; it would thus be analogous with the Wealden Shales, in which the red colour is absent, but in which a freshwater fauna, with a few estuarine forms intermingled, makes its appearance. Lastly, the incursion of the sea was marked in both cases by a sudden change of fauna and the occasional destruction of animal life during the rapidly varying conditions, as witnessed by the Rhætic bone-beds in the one case, and by the conglomeratic Perna Bed in the other.

The transition from the Continental period which preceded and led to the deposition of the Trias, and during which the greater part of the denudation of the Palæozoic rocks was accomplished, to the marine conditions which prevailed throughout the Jurassic epoch, is thus illustrated in every stage. Rarely is it possible to draw such a series of restorations of the geography of a distant geological epoch as is presented by the gradual isolation of the last prominences of the old Continent

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in the Triassic waters, and their final overwhelming by the Liassic sea.

Good sections of the top or whole of the "tea-green" series occur in road-cuttings at Lady Hill Farm south-west of Bishpool, and in a tramway at Coed Goleu, south of the twelfth mile-stone from Chepstow (p. 75). A boring for water at Great Traston, two miles south-east of Newport, seems to have been in New Red Marl to the bottom :—*

		ft.	in.
Tidal Alluvium	Clay	39	0
	Gravel	3	0
New Red Marl	Soft marl	1	0
	Grey gritty marl	29	0
	Hard red marl, red rock, and clay	299	6
		371	6

On the other hand, a boring at Messrs. Morris and Griffin's works on the east bank of the Usk west of Somerton seems to have been in Old Red Sandstone† :—

		ft.	in.
Tidal Alluvium	Blue clay	20	0
	Black clay	16	0
Old Red Sandstone	Hard grey stone	4	0
	Gravel with red and grey stones	2	0
	Red marl and sandstone	7	0
	Blue marl	3	0
	Red marl	7	0
	Red sandstone	24	0
	Red marl	3	0
	Gravel and running sand (slipped from above)	2	0
	Sandstone	5	0
	Hard red marl	99	0
	Red marl and sandstone	17	0
	Hard red marl with thin bands of sandstone	63	0
		272	0

RHÆTIC BEDS AND LIAS.

These two formations are so closely united that they may be conveniently described together. The best sections occur near Lis-Werry and Milton, but the small exposure at Goldcliff, just beyond the margin of the map, is noteworthy on account of the occurrence of organic remains in the usually barren "tea-green series" below the Rhætic Beds, as here defined. At Maes-glas, Lias, Rhætic Beds, and Keuper are all exposed, but generally faulted against one another.

* Communicated through Mr. A. C. G. Cameron.
† Communicated by Messrs. A. Williams & Co.

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The removal of the "tea-green marls" from the Rhætic leaves about 18 or 19 feet of shales and thin limestones in that formation. At its base we have occasionally the thin conglomeratic layer before alluded to, but more frequently a thin ferruginous grit, which rests on a slightly eroded or washed surface of the green marls. Though there is perfect parallelism between the Rhætic Beds and Keuper, and no evidence of more than a trifling pre-Rhætic erosion of the latter, yet this line seems to constitute one of the most important divisions in the Secondary Rocks of South Wales for the reasons given above.

In their lower part the Rhætic strata consist chiefly of dark shales, the principal home of *Avicula contorta*, which gives its name to the zone. Upwards they contain thin bands or septaria of limestone, and at the top a fine white limestone known as the White Lias, which, however, is not so well developed as in Somerset. They are conformably overlain by the Lower Lias, a part only of which, belonging to the zone of *Ammonites planorbis*, has survived denudation in the area under description.*

At Lis-Werry the Lower Lias limestones are being burnt for hydraulic (Blue Lias) lime. The strata dip at 5° to 10° to the south-east and about 15 or 18 feet of alternations of limestones and clays are removed from the dip-slopes, the limestones ranging from ½ to 1½ feet in thickness. *Ostrea liassica* abounds here as at Penarth, where the lowest Lias strata have been termed the Ostrea beds, and *Lima gigantea* is recorded by Mr. Woodward. Portions of the vertebral column of a *Plesiosaurus* found in 1881 were identified by Professor Sollas, and placed in the Bristol Museum. The following analyses have been communicated by Messrs. John Davies and Co.; the cement was analysed by Messrs. Holland and Phillips in 1883, the limestone by Mr. H. Faija in 1885:—

—	Lis-werry Cement.	Lis-werry Limestone, dried at 212° F.
Silica	16·04	9·35
Alumina	7·81	6·25
Ferric acid		traces
Sulphuric acid	1·22	—
Carbonic acid	6·23	78·45
Lime	64·32	
Magnesia	1·49	—
Potash	1·16	—
Soda	0·37	—
Organic matter	1·36	—
Loss at red heat, combined moisture, etc.	—	5·70
	100·00	99·75

* For a general description of the Lias the reader is referred to the Geological Survey Memoir on the Jurassic Rocks of Britain, vol. iii. The Lias of England and Wales, by H. B. Woodward, p. 121 (1893).

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Towards the north-west the Liassic dip-slope terminates in a bold little scarp formed of the Rhætic and upper Keuper strata, and a road-cutting at Lady Hill Farm furnishes the lower part of the following section:—

Lady Hill, Lis-Werry.

		ft.	in.
Lower Lias	Limestones, irregular with partings of clay and shale	8	6
	Limestones, more even with very thin partings of shale	8	0
	Paper-shales	3	6
Rhætic Beds, 22ft. 10in.	Limestone, blue-hearted but weathering white; the upper and lower parts shelly, with *Modiola minima* abundant, the middle part smooth-textured and pale; faint arborescent markings in places (equivalent to Cotham Stone)	1	0
	Pale-blue shale, passing down	1	4
	Light-coloured marl, indurated in parts	5	6
	Blue shale	4	6
	Sandy layer with fibrous carbonate of lime ("beef") and nodular limestone	0	3
	Blue shale with a line of oval nodules of limestone at the base	4	6
	Blue shale	4	0
	Quartz-sand, deep-red but occasionally white; in places cemented by iron-pyrites into a hard rock	0	3
	Interlaminated shale and sand, with calcareous bands	1	6
Keuper Marl	Greenish and yellowish rocky marl with fine sandy bands passing down	13	0
	Brick-red marl with greenish patches in the upper part, seen to	15	0

The uppermost limestone of the Rhætic group is generally recognisable and may correspond to the White Lias of other districts, but seems to be more closely linked with the Rhætic than with the Lias in South Wales. *Modiola* commonly abounds at this horizon. This section was noticed by Mr. J. E. Lee, who mentioned the occurrence of *Desmacanthus cloacina*, and observed a bone-bed in "patches."*

At Bishpool the thin band of quartz-sand lies 2 feet above the base of the Rhætic, and the interlaminated shale and sand below include some dark impure limestone. A fine-grained sandy layer, 3 feet in thickness, occurs in the "tea-green" series, 2 feet below the Rhætic base.

* Note Book of an Amateur Geologist, 1881, Pt. XII. and p. 35.

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Tramway Cutting in Coed Goleu, near the Twelfth Milestone from Chepstow.

		ft.	in.
Lower Lias	Alternations of limestone and shale, the former burnt for lime, and used for building	—	
	Shale	3	0
	Shelly stone	0	6–8
	Shale	2	6
Rhætic, 20ft. 11in.	Impersistent smooth-textured limestone with dark streaks, sometimes becoming a "landscape-marble" (Cotham Stone)	0	6
	Shelly limestone with *Modiola minima*, with an irregular band of smooth-textured limestone	0	6
	Pale-blue shale	3	0
	White marl passing down	4	0
	Black shales	11	0
	Ferruginous grit	0	8
	Shale and sandstone, rubbly, 1ft. to	1	3
Keuper	Green marls, seen to	2	0

At Goldcliff the cliff has been faced with masonry, but limestone, in which Mr. Woodward observed *Ammonites planorbis, Modiola minima, Ostrea liassica,* and *Cardinia,* is exposed at the top of it, and in one spot, 70 yards west of the barn, the fine-textured uppermost Rhætic limestone of Lis-Werry and Coed Goleu is seen at the top of the wall. A small breach in the bottom of the wall gives access to the base of the Rhætic as below:—

Goldcliff.

		ft.	in.
Rhætic (part of)	Coarse ferruginous grit	1	0
	Shale	0	1
	Hard dark-blue grit with bones and small pebbles of grit	0	6
	Hard siliceous and ferruginous layer	1 to 2	
	Green marls, with a bone-bed, seen to	8	0

The base of the Rhætic is conspicuous and sharply defined, and the green marls below it exhibit the cuboidal weathering so commonly seen in the Keuper. The occurrence in them, however, of a "bone-bed" is quite exceptional.* The bones occur in what seem to have been sinuous and irregular runlets excavated

* The earliest notice of this bed was that by Mr. Lee, *Brit. Assoc. Report* for 1872, sections, p. 116. See also Note Book of an Amateur Geologist, 1881, p. 72, and Plates clxxi. and clxxii. Mr. Woodward first observed the fact that it occurred some little way down in the green marls, and not at their top, *Proc. Geol. Assoc.*, vol. x., p. 538 (1888). Comparison may be made with a section in Warwickshire described by the Rev. P. B. Brodie in the *Quart. Journ. Geol. Soc.*, vol. xlix., p. 171 (1893), where the green marls of the Upper Keuper yielded fish-remains, &c.

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in a mud-flat, as suggested by Mr. Lee. The runlets became filled with coarse quartz-sand mixed with many scales and teeth of fish, and by the hardening of their contents now resist denudation better than the marl in which they were enclosed. They are well shown in the foreshore at the foot of the wall, about 5 feet below the base of the Rhætic beds; they vary from 3 to 12 inches in width, and can sometimes be traced for 7 or 8 yards. Among the fish, *Gyrolepis Alberti*, Ag. and *Hybodus minor*, Ag. have been recognised by Mr. E. T. Newton; *Saurichthys*, also, is quoted by Mr. Lee.

At Maes-glâs the Lower Lias and Rhætic are exposed in the river-bank and railway.* The former is quarried to a depth of 14 feet and burnt for lime. The strata dip south and south-east, so that the base of the Lias comes to the surface in and west of the railway, together with a triangle of the upper Rhætic beds. Six yards north of the road the cutting is crossed by a fault throwing the Lias down to the north, but 30 yards further on a second fault with a downthrow south brings up the red marl.

* The cutting has been widened and much altered since these notes were made.

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CHAPTER IX.

SUPERFICIAL GEOLOGY.

Glacial Deposits.

The district described in this volume lies on the margin of the Drift-distribution of Brecknock, Glamorgan, and Monmouthshire. It will be shown in the publications descriptive of the more central parts of the Coal Field that the Old Red Sandstone escarpment of Brecknock was not less important as an ice-parting in Glacial times than it is as a water-parting at the present day, and that the ice-streams from it traversed the Coal Field by the great valleys which give passage to the existing rivers. The larger escarpments in the Coal Field themselves also formed subordinate ice-partings, and contributed to the materials of the southward-travelling Drift.

It thus happens that the Glacial deposits of the southern parts of the Coal Field consist principally of Coal Measure *débris*, but that material from a more distant northern source has found its way down here and there wherever opportunity offered. Thus boulders derived from the Brecknock outcrops have travelled down the Sirhowy Valley to Blackwood and down the Rhymney Valley to Caerphilly, while in the Taff they occur in such numbers as to suggest that some at least must have found their way out into the maritime plain. Of the rivers traversing the eastern end of the Coal Field the Taff alone rises in the Old Red Sandstone, the others collecting their head-waters in the Millstone Grit and Limestone of the North Crop.

It will be further shown that, though the Drift gained egress from the hills of the Coal Field to the maritime plain by way of some of the valleys which breach the South Crop, it does not, and probably never did, extend much further south than the Ely Valley west of Cardiff or the coast-line between Cardiff and Newport. Near Newport, not only its southern, but its eastern limit is well defined, and to the east of the Ebbw Valley, except for some insignificant patches along the Afon Lwyd, Drift is conspicuously absent; nor do we find any Glacial deposits, beyond a few scattered boulders, until we reach the Usk Valley, down which a great mass of gravel has travelled round the north-east corner of the Coal Field.

From the consideration of a large number of striated rock-surfaces which have been observed it is inferred that the true direction of the glaciation was rather east of south in Monmouthshire, though it was, of course, locally deflected by the main valleys. The inference is borne out by the fact that the longer axes of the ridges and mounds into which the Drift was piled, and many of which retain their original outlines, also point in that direction.

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The Boulder Clay or Sand and Gravel into which the Glacial Drift is classed shade into one another, partly owing to the gravelly nature of the Boulder Clay where it has been derived from sandstone-areas, but partly also in consequence of a gradual passage from the Boulder Clay type horizontally into the Sand and Gravel type at a distance from the source. The tough till packed with scratched blocks near the ice-parting becomes a pebble-gravel near the ice-foot, nor can it be determined that either is older than the other. The difficulty is increased by the fact that in nearly all sections where both types occur they have been so inextricably jumbled up, apparently by the action of the ice, that no separation on the map is possible. Marine shells are unknown in the Drifts of Monmouthshire and Glamorganshire.

(1). *The Afon Lwyd Valley.*

Two patches of gravel occur on the east of this valley, the upper one at a height above the sea of 350 feet, but falling to 300 feet southwards, and about 130 feet above the river; the other, near Llanfrechfa, lies about 100 feet lower, and is only about 60 feet above the river. They seem to be remnants of a sheet or strip of gravels following the general course of the Afon Lwyd, though their mode of occurrence shows that much of the valley has been excavated since their deposition. They consist of pebbles of grit and pebbly grit, generally well rounded, and have probably been derived solely from the drainage-area of the Afon Lwyd. The patch at Caerleon is of doubtful origin and extent. Red clay, with bands of gravel containing large grit-pebbles, is exposed to a depth of 10 feet in the railway-cutting; it has neither the form, appearance, nor position of a river-terrace, and by inference is Glacial.

(2). *The Ebbw and Sirhowy Valleys.*

The Glacial gravels of the Ebbw Valley attain a considerable thickness, but are hemmed in to a narrow space by the steep hill-sides. Though doubtless they once overspread the whole valley-bottom, they have been deeply denuded, and occur now only as fragmentary terraces rising to a height of 30 feet to 40 feet above the alluvial flat, or have even been completely washed away, as at Crumlin and Llanhilleth. They are generally composed of coarse, well-rounded Coal Measure *débris*, roughly stratified, but the small strip shown in the Glyn Valley is partly made up of buff laminated sand with streaks of coal-dust, and the tunnel close by is said to have traversed gravel and quicksand.

The terrace on which Cwm Carn, Pont-y-Waun, and Crosskeys are built is a characteristic example, and the gravel of which it is composed can be studied in several little ravines in the little cliff which overlooks the alluvial flat. At first sight such terraces might easily be mistaken for post-Glacial river-terraces, but their height above the stream, and more especially the fact that their surface bears little relation to the gradient, but rises and falls

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into the ridge and hollow so characteristic of Glacial deposits, furnishes the evidence of their true age. The Celynen and Abercarn Colleries are both situated on the alluvium, but the Risca No. 1 Pit (Vert. Sections, Sheet 80, Section 14) was sunk through a terrace of Drift in the lower part of the Sirhowy Valley and proved 60 feet of gravel. The deposit is exposed to a depth of 50 feet in the steep edge of the terrace close by. The Cwm Carn Shaft, as shown in the section given on p. 36, traversed no less than 76 feet of Drift, of which the lower 9 feet consisted of sand.

Near Ynys-ddu the Sirhowy Valley narrows to a ravine in Pennant and has been clean swept of Drift, but it expands again in the Mynyddislwyn measures, and contains much Boulder Clay. Some of this has come along a transverse depression from Maes-y-cwmmer, as is proved not only by the form of the ground but by the occurrence of striæ pointing E. 5° S. in the railway-cutting 330 yards west of the tunnel. The rock-surface was here exposed by the removal of about 20 feet of Boulder Clay, with many pebbles and blocks of Coal Measure grits, but no foreign rocks.

On the south side of Blackwood a similar deposit is exposed to a depth of 40 feet, but northwards it passes into a coarse pebble-gravel and sand, well exhibited between Rock and Blackwood, where it was formerly dug for the Tredegar Iron Works. There lie here a few large glaciated blocks of Old Red Sandstone which must have come not less than twelve miles from the Brecknock outcrop; these are the only foreign and the only striated boulders noticed in the neighbourhood.

Gwrhay stands upon a conspicuous ridge of sand and gravel. The axis runs north and south, and a sand-pit, 40 feet in depth at the southern end of the ridge, exposes horizontally bedded loam and running sand with coarse gritty bands. Both above and below the sand there occur coarse pebble-gravels composed almost wholly of Coal Measure Sandstones, and in it dust and pebbles of coal abound. Similar sand was dug under the Church, but a few yards away, both to the north and south, the sand and gravel give place to Boulder Clay. A similar ridge, or "esker," has been cut through by the railway at Pen-rhiw-eglwys.

A level in Cwm Crâch, on the opposite side of the river, intersected what the miners called a "sand-bar," or a "gravel-fault," by which was meant a pre-Glacial ravine which had been filled up with Drift. In this instance the level passed from the coal into a clay with subangular stones of local origin, but regained the coal after having been driven a further distance of 40 yards. Several such "bars" are said to have been found in the Gwrhay Colliery.

At Pen-coed-fawr, a mile to the west, there lies on the watershed a broad spread of coarse gravel composed of pebbles of sandstone and pebbly grit, ranging up to 8 inches in length. It is to be noticed that the gravel is piled up into ridges running N.N.W. to S.S.E., and that as it lies on a nearly level plateau, this direction truly represents that of the Drift-transport. A few small blocks of Carboniferous Limestone and Old Red Sandstone occur both here and at Argoed, while some of the pebbly grits are probably

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Millstone Grit, but the vast majority of the boulders have been derived from the Coal Measures.

A large quantity of Drift, in the form of gravel or very gravelly Boulder Clay, found its way out from the hills by the way of the Ebbw Valley at Risca. It assumes the form of ridges running N.W. to S.E., and enclosing water-logged hollows, a feature which is well shown near Mount Pleasant and Great Oak. It is seen to a thickness of 40 feet in the banks of the canal and of upwards of 20 feet in the railway a mile north of Ty-du, where it includes a contorted and eroded band of grit and sand. At Rogerstone Castle copious springs issue from it at the level of the alluvium.

Towards its northern margin, near Risca, the gravel is extremely coarse, and includes among the mass of Pennant-pebbles many large boulders of pebbly grit and angular blocks of Old Red Sandstone, all probably of strictly local (South Crop) origin. Towards the south-east it becomes finer, and forms a gently undulating plateau, terminated by a fairly conspicuous feature which is obviously the result of post-Glacial denudation. It is not probable, however, that the gravel ever extended much further in that direction.

On the west side of the Ebbw the Drift contains somewhat more clay, derived probably from the Old Red Marls. It contains striated boulders, and its surface is dotted over with numerous water-logged hollows formed by the coalescing of the Drift-mounds and ridges. Most of these hollows have been filled up by vegetable growth, &c., and some have been drained, but a few still exist as lakelets. These highly characteristic features are well exhibited between Castletown and Llanishen.

(3). *The Rhymney and Aber Valleys.*

In the Rhymney Valley there was more space for the deposition of Drift than in those just described. North of Maes-y-cwmmer the Boulder Clay type prevails, but thence southwards well-rounded gravels arranged in mounds and ridges, and enclosing many water-logged hollows, form the bulk of the deposit.

The Bargoed-Rhymney, a mile above Bargoed, contains much pebble-gravel of purely local origin, but lower down there is roughly stratified stony clay with sand. In the main valley at Bargoed the Drift, though gravelly here and there, is of the Boulder Clay type, and contains striated boulders of sandstone. It is visible to a depth of 40 feet at Fiddler's Elbow, 400 yards above Bargoed Junction, and a level 700 yards north of the Junction ran for 400 yards in it before reaching the solid rock.

At Maes-y-cwmmer the Rhymney ice-stream received a tributary from the north-west by way of Llancaiach, along a transverse depression corresponding to that which connects the Rhymney and Sirhowy Valleys (p. 79). There also striæ on rock-in-place plainly indicate the route followed by the ice; they are beautifully shown at the junction of the Great Western Railway with the Ystrad branch-line, and less well in the Rhymney Railway 400 yards south of Ystrad Junction. A

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notable exhibition of Glacial phenomena is furnished by a disused paving-quarry 700 yards west of the Junction; here there rest upon the rock about 20 feet of a jumble of Coal Measure *débris* in clay with an occasional boulder of Old Red Sandstone, and with a broken and twisted mass of a coal and its underclay, about 5 or 6 feet in length, which has been pushed down bodily from the outcrop further west. This "till" rests upon a well-glaciated floor of sandstone, the striæ on which range E. 25°—33° S.

At Ystrad Mynach there is a fine development of highly characteristic Drift hillocks and hollows, and at Pwll-y-pant Quarries some striæ were noticed pointing obliquely across instead of along the Rhymney Valley, probably in consequence of the form of the ground.

The Caerphilly Basin, which the Rhymney enters at Pwll-y-pant, is not only structurally a syncline, but physically a deep hollow, and has caught vast quantities of Glacial gravel in its journey southward. The deposit is coarse and has been heaped up into most irregular ridges so as to enclose a labyrinth of peat bogs and alluvial flats. Through these the rivers wander at haphazard, having found their way from one hollow to another at what happened to be the lowest outlet. Though they have long since established courses with regular gradients, they must originally have formed a series of lakes connected by rapids; thus the Rhymney below Bedwas Bridge has excavated a gorge in a barrier of gravel for about 400 yards, but until it did so the alluvial flats above, which are clearly original features and not due to post-Glacial erosion, must have been submerged.

The thickness attained by the gravel is considerable. The Cwm-y-glo Shaft passed through 87 feet of it, and the Rhos Llantwit Pit 66 feet before reaching the rock. Near Eneu'r-glyn Colliery upwards of 20 feet of gravel with large boulders of Pennant are shown, and at Tir Gibbon Colliery a sand-pit exposes four feet of coarse gravel with a few boulders of Old Red Sandstone resting on fine current-bedded sand and loam. Caerphilly Castle is built on mounds of the Glacial gravels and the railway-cutting east of it traverses a roughly stratified coarse deposit with large blocks of Pennant and a few pebbles of Old Red Sandstone. Westwards, near Penrhos House, a cutting shows upwards of 30 feet of coarse gravel, underlain apparently by beds of sand and clay, which, however, are obscured by landslips.

The Aber Valley, by which also vast quantities of *débris* have reached the Caerphilly Basin, contains in its lower part a coarse pebble-gravel of local sandstone with two to four per cent. of Old Red Sandstone erratics. Much of it shows a rough stratification, but at Pen-yr-heol it becomes an unstratified gravelly till, exposed to a depth of 30 feet. Mounds of pebble-gravel are conspicuous at Aber-tridwr, and in the transverse depressions which lead up to Eglwysilan Church westwards and to Caer-llwyn eastwards, there are good examples of small eskers; in the former Old Red Sandstone boulders are common, together with

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pebbles of a very hard compact olive-green sandstone of unknown origin, and in the latter an unstratified till four feet thick rests on fine bedded sand. In the upper parts of all these valleys the Boulder Clay type of Drift prevails; the Universal Colliery, for example, proved that material to extend to a depth of 66 feet.

On the surface of the mountain crossed by Heol Fawr, a quarter of a mile north-west of Bryn, there are large numbers of great blocks of quartz-grit crammed with quartz-pebbles, and much resembling Millstone Grit. By Prof. Edgeworth David* they were attributed to that formation and to the Old Red Sandstone, and though similar pebbly bands are not unknown in Coal Measure Grits, their profusion in this spot and the absence of any suggestion of an outcrop favours the correctness of his view.

The Rhymney Valley, like the others, provided an exit for the Glacial Drift from the hills of the Coal Field on to the maritime plain. The material is generally a coarse gravel along its northern margin, but southwards becomes a fine sand with small pebble-gravel. Its deposition in mounds and ridges is forced on the attention everywhere, and little water-logged hollows abound, but the ridges, unlike those confined within the sides of deep valleys, have no regular trend. Coal Measures have yielded the mass of the boulders, but Old Red, Limestone, and Millstone Grit blocks from the South Crop are common, and a red tint prevails. The Rhymney River, in cutting its way through this labyrinth of Glacial mounds, has dissected several of them, and at Woodvale House its banks show upwards of 60 feet of coarse gravel, partly cemented into a rock.

(4). *The Taff Valley.*

From the fact that the sources of the Taff lie in the Old Red Sandstone it might be expected that a freer passage would be afforded to the Brecknock Drift by this valley than by those just described which lie wholly within the Carboniferous area. The anticipation is confirmed by the fact that limestone-boulders abound near Quaker's Yard, and that Old Red Sandstone is far from uncommon along the whole length of the river. It was by way of the Taff Valley also that the Brecknock boulders seem to have found their way past Llancaiach into the Rhymney Valley and the Caerphilly Basin.

The Bargoed-Taff, which joins the Taff at Quaker's Yard, rises on the Millstone Grit near Dowlais, and accordingly differs from the main valley in its contents. Near Cwm-felin, and for a mile south of it the Drift was found by Mr. Gibson to consist of local rocks only, embedded in a stiff clay; southwards it becomes chiefly a gravel, but whether gravel or clay it contains boulders of Old Red Sandstone, while still further south, between Quaker's Yard and Navigation, it is largely made up of the *débris* of that rock together with much well-scratched Carboniferous Limestone. From these facts Mr. Gibson infers that the far-

* *Quart. Jour. Geol. Soc.*, vol. xxxix., p. 42. 1883.

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travelled boulders reached the district by way of the Taff and not by way of the Bargoed-Taff, and that the Taff iceflow bifurcated at Quaker's Yard, part of it following the main valley, and part of it taking the Llancaiach route referred to above. The nature of the far-travelled Drift, and especially the manner in which it has been banked up against a steep rock-face, is finely shown in a cutting on the Rhymney Railway 450 yards south-east of Quaker's Yard Junction (Fig. 4).

There it may be described as a till or gravelly till with scratched blocks, especially of limestone, in abundance, but in a quarry by the roadside at Pont Newydd Mr. Gibson observed several feet of coarse gravel with pebbles of Old Red Sandstone and large blocks of Pennant, resting on roughly stratified sand. In the Park and Pandy quarries he also found contorted sand and gravel resting on stony clay, sometimes passing down into it, but occasionally with a sharply defined plane of separation. Here there were included with the usual mass of Pennant blocks 5 per cent. of pebbles of Old Red Sandstone and some of pebbly grit; many of the boulders being embedded in a vertical position (Fig. 5).

Near Llancaiach pebble-gravel forms characteristic mounds and ridges, one of which runs out as a headland into the alluvial flat 1,200 yards east of the Station. The longer axes of these gravel-ridges point towards Ystrad, and thus confirm the inference we have already drawn from the striæ (pp. 79, 80), as to the movement of the ice along the transverse depression.

The southern part of the cutting on the Rhymney Railway south of Quaker's Yard traverses Boulder Clay, with large blocks of Pennant and some boulders of Old Red Sandstone and limestone, nearly to Navigation (Abercynon), the deposit being upwards of 50 feet thick in places; but at Navigation, where the Cynon River joins the Taff, sands and gravel are well developed. In a small quarry on the road to Mountain Ash Mr. Gibson observed Glacial sands under the more recent river-gravel, and around Navigation there is much coarse gravel, often containing huge blocks of sandstone. Similarly at Quaker's Yard Junction the Drift takes the form of coarse gravel, so that we arrive at the conclusion that the Boulder Clay type is confined, in this particular neighbourhood, to that part of the Taff Valley which trends south-westwards, that is across and not in the direction of the glaciation. This accords with observations made in other parts of South Wales, that the gravelly type of Drift is developed chiefly along the lines of drainage, and, on the supposition that the pebble-gravels were the work of effluents from the ice-sheet, leads to the inference that the existing rivers follow the routes taken by those effluents.

The hillside south of Navigation is well glaciated * almost up to its top, the two examples recorded on the map being 680 and 750 feet above the sea, or 420 and 490 feet above the river. It is

* Striæ were first recorded from this neighbourhood by Prof. Edgeworth David, *Quart. Journ. Geol. Soc.*, vol. xxxix., p. 51. 1883.

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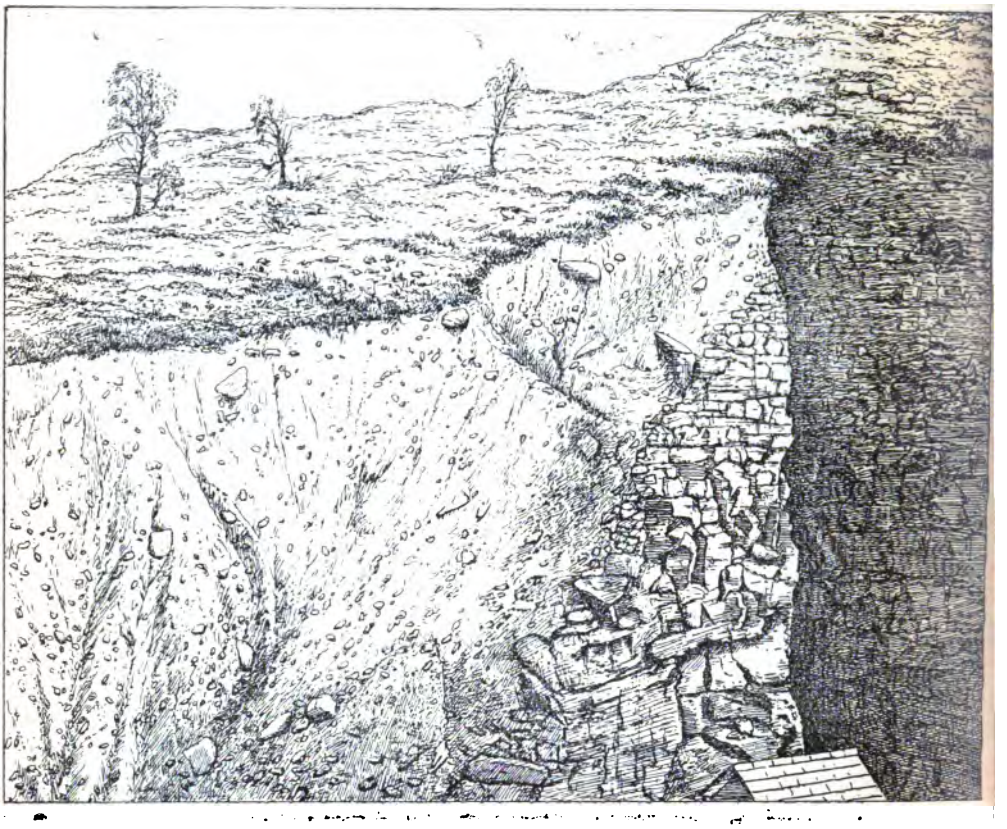

Figure 4.—*Boulder Clay with much scratched limestone, banked against a steep slope of Pennant Grit, near Quaker's Yard.*
Drawn by H. W. G. WILLIAMS from a Photograph.

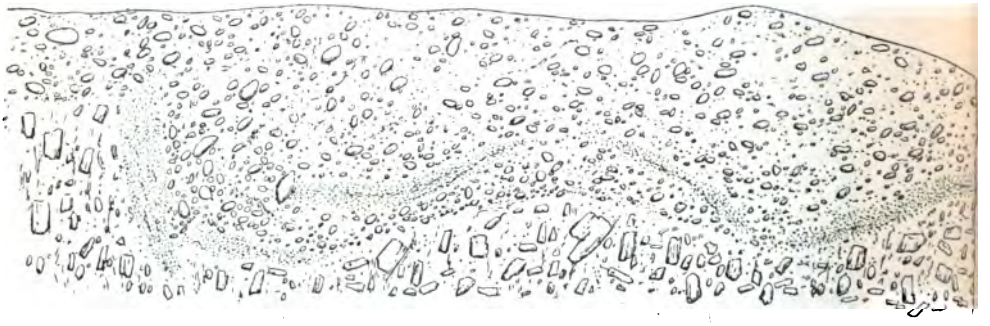

Figure 5.—*Contorted Gravel and Boulder Clay near Llancaiach.*
Scale one inch to nine feet.
From a Sketch by W. GIBSON.

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probable that the valley was filled to overflowing, for in this way only could the occurrence of the erratics on Mynydd Eglwysilan (p. 82) be explained.

At the Berw Aqueduct near Pontypridd the river-cliff exposes 45 feet of coarse gravel, but the side streams of Nant-cae-dudwg and the Ely Brook near Pont-Shon-Norton have cut ravines in Boulder Clay with large striated boulders, here again the gravels keeping along the line of drainage. Striæ on rock-in-place have been noticed at the northern margin of Coed-pen-main Common, with the direction S. 5° E., and in several places near Lan (Sheet 248), but abound especially along the west side of the valley further south. They occur in the Taff Vale and Barry Junction Railway close to the Treforest Tin Works, in a quarry 400 yards west of the Salmon Arms, in many places near Pant-Evan-ddu, and in the Barry Railway 300 yards north of its crossing by the Llantrisant branch-line. They range approximately down the valley, in a general direction S. 15°—27° E.

Coarse gravels assume their usual moundy form between Glyn Taff and Nant Garw, and extend thence eastward to join the Caerphilly deposit. A little lower down the expansion of the Taff Valley in the soft lower Coal Series leaves room for some highly characteristic gravel-ridges, and it is noteworthy that Old Red Sandstone from Brecknock forms about 10 per cent. of the boulders. How much farther they extend it is difficult to say, for the valley soon crosses the south crop of that formation, the boulders from which are indistinguishable from those of Brecknock. The banking up of the gravel against the steep walls of the limestone-ravine is remarkably shown in a quarry 300 yards north-west of Castell Côch.

Much of the ground west of Taff's Well is overspread by a clay full of stones of local derivation. From its thickness, its habit of rising into low rounded hills or drumlins, and from its containing an occasional striated stone it seemed to be a true Boulder Clay. It passes laterally, moreover, into undoubted Glacial gravels, and what is no less conclusive it keeps its character and composition considerably south of, and above, the outcrop of the rocks from which it is made up, and covers up large tracts of limestone with Coal Measure *débris*. This is the character of the deposit shown on the map as Boulder Clay to the west of Garth Wood.

POST-GLACIAL DEPOSITS.

River Gravels (Terraces).

Terraces of gravel, rising to a height of 4 to 15 feet above the alluvial flat occur in all the principal valleys and form the site of many of the colliery villages. They mark stages in the process of river-erosion and are best developed where the valley has contained much Glacial gravel; they consist, in fact, principally of Glacial material rearranged by fluviatile action.

In the Afon Lwyd terraces of considerable area occur at Llantarnam, Pont-newydd, and Panteg, and bear witness to the great erosion suffered by the Glacial gravels described on p. 78. The

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Ebbw and Sirhowy Valleys are too narrow to admit of more than narrow strips, but the development of a gravel-fan at the point where the Ebbw enters upon the alluvial flat of the Bristol Channel is noteworthy. The gravel forms a terrace, sometimes as at Coedcernew sloping up gently, at others rising abruptly from 6 to 10 feet above the marsh-level and ascending gradually to as much as 30 feet above it inland. It consists of well-rolled and roughly stratified material such as may have been derived from the Glacial Gravels further up the valley. Its deposition has ceased and it is now undergoing denudation by small streams and by the lateral swinging of the Ebbw. A similar gravel, perhaps continuous and contemporaneous with that of the terrace, underlies the alluvial mud at a lower level by about 50 to 70 feet.

This deposit seems to have been spread by the Ebbw when it commenced the excavation of its post-Glacial valley, and when its gradient was steeper than it is now. The best sections occur in the banks near Pont Ebbw and Maes-glâs, in a pit 500 yards south of Tredegar House, and in a pit at Pen-carn. It may be noted that much of Cardiff is built upon a similar fan connected with the Taff. No implements have been recorded from these deposits, but the gravels are comparable to some in the South of England which have proved rich in palæolithic remains.

There are terraces along much of the Taff Valley, especially at Quaker's Yard, Navigation (Abercynon), Treforest, Upper Boat, Glan-y-llyn and Taff's Well. At the last-named the terrace-top is 15 to 25 feet above the alluvial flat, and the steep bank dividing the one from the other is well seen near the warm spring. A second little cliff showing upwards of 50 feet of Glacial gravel crosses the Rhymney Railway east of the canal and marks the outer margin of the river-terrace.

Recent Alluvium.

A small portion of the alluvial tract known as the Went-loog Level falls within the map under description. In several borings and in the excavations for the Newport Docks the deposit has been shown to consist of tidal mud and silt to a depth of about 40 feet, or 20 feet below Ordnance Datum, and to be underlain by a small thickness of gravel. At Great Traston the mud was 39 feet and the gravel 3 feet thick with New Red Marl beneath, while at Messrs. Morris and Griffin's Works on the east bank of the Usk there was blue clay for 20 feet, black clay for 20 feet, and then red sandstone (p. 72). An excavation for a new dock at Newport in 1891 showed 40 feet of clay and sand resting on gravel. Bones of deer are said to have been found in the gravel.

Peat.

Peat-bogs occur on the moorlands, but not abundantly. One such bog, known as Waun-rhydd, lies south-west of Gelligaer Church, and several are dotted about Mynydd Eglwysilan; there is in addition much ground covered by a peaty soil 1 to 2 feet

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thick, especially along the outcrops of strata that throw out water, whether coal-seams or shale-bands, and also along the courses of faults where the shattering of the rock has often led to the formation of a line of hollows. Many of the water-logged hollows enclosed by Drift-ridges are occupied by peat, notably in the Caerphilly Basin.

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APPENDIX.

WATER SUPPLY.

The sources of water-supply of the populous area described in the foregoing pages are too numerous to be treated in detail in this volume, but a few words may be devoted to indicating the general character of the strata in this connection. The formations may be grouped into :—

(1) Impervious, in which must be included the Lias, Rhætic and New Red Marl, the upper or Llantwit Coal Measures, the lower or Steam Coal Series, the lower or marly sub-division of the Old Red Sandstone, and the Silurian Rocks.

(2) Pervious, in which may be classed the Pennant Grit, the Millstone Grit, and the upper or sandstone sub-division of the Old Red Sandstone. The Carboniferous Limestone, though completely impervious in its solid condition, is usually so honeycombed by underground water channels that it must also be included.

In making this classification it will be understood that some of the impervious formations include porous and water-bearing bands, but that these are subordinate : and that the pervious formations contain some subordinate water-tight beds of shale, such, for example, as those in the Pennant or Millstone Grit.

The bold physical features of the country provide frequent opportunities for the exhibition of the water-yielding capability of the formations named above. The table-land formed by the gently inclined Pennant Grit is intersected by valleys at somewhat regular intervals, and in the sides of each of these crop out the massive grits and the subordinate beds of shale, clay, and coal which compose that formation. Under such circumstances the rain which is absorbed upon the mountain-land breaks out in lines of springs along the outcrops of the impervious partings, and more especially along the outcrops of the coal-seams. The springs occur all along the outcrops, but are much more copious on that side of the mountain to which the strata dip, and where the impervious band descends to its least elevation. These sources of water have been extensively opened out in the process of mining by levels driven in under the mountains from the crops of the coals. Many of these levels, when favourably situated with reference to the dip, yield large quantities of water, but nearly always too highly chalybeate to be available for purposes of water-supply. Many of the natural springs, however, are not too chalybeate to be used, though they are generally harder than is convenient. They form the source from which a large portion of the population in the Coal Fields is supplied.

The Carboniferous Limestone yields but few springs in the district under description, in consequence no doubt of its uniformly high dip to the north and its narrow outcrop.

The upper beds of the Old Red Sandstone, in spite of their similar position, yield a number of good springs along the hill-side north-east of Risca, which are collected to form part of the supply of Newport.

A portion of the district is supplied by the impounding of surface-water on the Millstone Grit moorland to the north of the Coal Field. A reservoir for the further supply of Newport is in course of construction upon the Old Red Sandstone near Wentwood, to the east of Sheet 249.

From these remarks it will be seen that there are no deep wells of any consequence, the low-lying part of the area being underlain by either red marls or Silurian Rocks. The absence of the conglomerate at the base of the New Red Marl is unfortunate for the prospects of obtaining water by wells sunk through that formation.

The Drift Sands and Gravels yield a number of small springs, which, however, come under the head of surface-waters, and are liable to pollution in populous regions.

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TAFF'S WELL.

This tepid chalybeate spring is used as a cure for rheumatic affections. The spring rises in the alluvial flat of the Taff, close to the banks of the river, but has been enclosed in a circular covered bath. In the construction of the bath the ground was excavated to a depth of about 10 feet, and a clay with black coaly *débris* was reached which was believed to be the crop of the Brass Vein. The hole was walled round and filled with pebbles for about 5 or 6 feet, over which were placed perforated boards. The overflow pipe is about 5 feet above this floor, but if it is plugged the water rises a foot higher and escapes by the door. The temperature of the water has been observed by Mr. F. T. Howard to be as high as 72°F., but on October 12th, 1895, I found it to be 55°F., and on October 19th 66·2° F., while Mr. Thomas* gives it as 65·6° F. These rapid variations probably depend on the amount of gravel-water mixing with the spring-water, and would therefore be connected with the rainfall.

Gas escapes with the water at a rate estimated by Mr. Thomas at 4½ cubic feet per hour, and when the river is low can be seen rising in the river-bed also. An analysis by Mr. Thomas shows the following composition :—

Gas from Taff's Well.

Carbonic acid	1·16
Nitrogen	98·84
Hydrocarbon gases	traces
	100·00

Mr. Thomas also analysed the solid residue obtained by evaporating about 15,000 grammes of the water, with the following result : No. 1 analysis gives the composition of Taff's Well water in 1875, No. 2 of the same water in 1877, and No. 3 of a spring 120 yards further up the river:—

	No. 1 Analysis.	No. 2 Analysis.	No. 3 Analysis.
Total solid contents: parts in 1,000,000	290	293	228
	Constituents of solid contents ; parts in 1,000,000.		
Calcium (Ca)	44.5	43.7	48.7
Magnesium (Mg)	18.3	17.9	9.4
Sodium (Na)	31.0	—	—
Potassium (K)	1.3	—	—
Aluminium (Al)	trace	trace	trace
† Oxide of iron (Fe_2O_3)	7.1	7.4	14.1
Manganese (Mn)	0.6	0.7	traces.
Carbonic acid (CO_2)	112.5	not estd.	not estd.
Sulphuric acid (SO_4)	23.8	23.1	—
Phosphoric acid	traces	traces	—
Chlorine (Cl)	35.5	36.0	8.1
Nitric acid (NO_3)	—	—	1.6
Silicic acid ($Si O_2$)	16.3	12.1	15.9
Specific gravity of water	100,028	100,029	100,026

* On the Water of Taff's Well, by J. W. Thomas, F.C.S., *Trans. Cardiff Nat. Soc.*, 1877, p. 48.

† The iron is calculated as oxide, as it existed in the residue used for the determination of the constituents of solid contents.

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——	Carbonic Acid.	Nitrogen.
Gaseous contents in cubic centimetres per litre at O°C. and 760 mm. pressure of Taff's Well water - - - - -	34	58

The temperature of the water may be due either to the spring being very deep-seated or to chemical action. The evolution of nitrogen points to the latter explanation, for this gas is almost certainly the residue of air which has been carried down and deprived of its oxygen in the process of oxidising some decomposing mineral. We have already shown that the spring probably issues from the intersection of the Brass Vein by a north and south fault, and that that vein yields a strong "mineral water," said to resemble Taff's Well water (pp. 48, 57). The decomposition of the iron-pyrites, from which the vein derives its name, is the probable cause of the peculiarity both of the water and of the gas evolved.

ANALYSES OF LIMESTONES,

Made for Mr. F. T. Howard. F.G.S., at St. Mungo's College, Glasgow, under the superintendence of Prof. T. Rhymer Marshall, D.Sc., etc.

——	1	2	3	4	5	6
Free silica, SiO_2 - -	·56	—	—	—	30·39	1·48
Clay, Al_2O_3, $2SiO_2$, $2H_2O$	·41	1·38	12·47	3·33	1·94	·23
Calcium carbonate - -	84·58	96·20	80·96	59·55	44·15	88·89
Ferrous carbonate - -	·45	·13	2·46	2·18	10·52	1·56
Ferric hydrate - -	10·17	—	·53	—	·71	·41
Magnesium carbonate -	2·65	1·33	1·71	31·00	7·51	3·69
Coaly matter - - -	2·76	·40	1·42	—	2·34	—
Moisture, etc. - - -	·67	·56	·45	·31	—	·55
Calcium sulphate - -	—	—	—	3·63	2·24	—
Manganese carbonate -	—	—	—	—	—	3·19
	100·00 [102·25]	100·00	100·00	100·00	99·80	100·00

1. Walnut Tree Limekiln, upper zone, top-quarry—Carboniferous Limestone.
2. Do., middle zone, bottom black limestone of top-quarry.
3. Do., middle zone, oolitic portion.
4. Do., station end of big quarry.
5. Do., shale-band opposite Canal Stage.
6. Common Coed-y-paen, Usk Inlier, Wenlock Limestone.

ANALYSIS OF IRON ORES.*

Of these iron-ores the first six are from the Coal Measures, the Black Band of Abercarn being the bed referred to on p. 51. The seventh is an alteration-product in the Carboniferous Limestone; it is described as being "oolitic and sometimes pisolitic," a character which is conspicuous in the Rhubina ore. No quantity of ore, however, was raised from that spot. On the other hand, I am not aware that the deposits at Garth, from which the bulk of the ore was raised, ever show an oolitic structure. The exact locality of the specimen must, therefore, remain in doubt.

* The Iron Ores of Great Britain (Memoirs of the Geological Survey), Part III., pp. 187-190, 192, 193, 217 (1861).

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—	Spotted Vein Mine (Balls) Pontypool. E. Riley.	Meadow Vein Mine. A. Dick.	Three Cakes Meadow Vein Mine, Pontypool. A. Dick.	Black Pin Mine, Pontypool. E. Riley.	Black Band, Pontypool. A. Dick.	Black Band, Abercarn. W. Ratcliffe.	Calcareous Hæmatite, Whitchurch (near Cardiff). W. Ratcliffe.
Protoxide of iron	44·50	32·44	26·03	26·98	31·74	43·37	1·131
Sesquioxide of iron	—	—	—	—	—	4·10	66·554
Protoxide of manganese	0·73	0·80	1·09	0·49	1·06	1·50	1·127
Alumina	1·35	0·24	0·37	1·19	7·75	6·05	1·753
Lime	1·91	3·66	8·14	3·11	3·84	3·00	8·547
Magnesia	2·47	3·69	5·48	4·13	3·51	0·25	1·116
Potash	—	—	—	—	1·12	0·32	0·190
Soda	—	—	—	—	—	—	0·068
Carbonic acid	30·92	26·15	28·29	23·40	25·03	30·50	5·733
Phosphoric acid	0·23	0·28	0·17	0·35	0·35	traces	1·017
Sulphuric acid	—	—	—	—	—	1·56	1·309
Silica, soluble in hydrochloric acid	0·22	—	0·24	0·50	—	—	0·312
Bisulphide of iron	0·11	0·30	0·69	0·52	0·48	—	—
Water, in combination	0·76	0·98	0·99	0·78	—	0·31	2·118
Water, hygroscopic	—	—	—	—	—	0·27	
Organic matter	0·21	1·15	0·41	0·82	8·50	6·25	0·376
Insoluble residue, chiefly silica and alumina	15·73	30·01	27·35	36·51	16·97*	2·80*	10·356
	99·14	99·70	99·25	98·78	100·35	100·28	101·707

* Given as "silica."

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